DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-161731

SOLAR HEATING AND HOT WATER SYSTEM INSTALLED AT CHARLOTTE MEMORIAL HOSPITAL, CHARLOTTE, NORTH CAROLINA

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Under Contract DOE-EX-76-C-01-2394

Monitored by

George C. Marshall Space Flight Center, Alabama 35812
National Aeronautics and Space Administration

For the U. S. Department of Energy

(NASA-CR-161731) SOLAR HEATING AND HOT WATER SYSTEM INSTALLED AT CHARLOTTE MEMORIAL HOSPITAL, CHARLOTTE, NORTH CAROLINA Final Report (Ferebee, Walters and Associates) 67 p HC A04/MF A01 CSCL 10A G3/44

N81-23606

Unclas 42329

U.S. Department of Energy

Solar Energy

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I. DESCRIPTION OF BUILDING AND FUNCTION

A. BUILDING DESCRIPTION

The Area Health Education Center at Charlotte Memorial Hospital and Medical Center is a combination administration and continuing education facility. The purpose of the building is to provide staff office space, classrooms, and resources to maintain a program for undergraduate, graduate and continuing education aimed at improving the quality, quantity and distribution of health manpower and education with a nine county area of North and South Carolina, of which Charlotte is the center.

The development of the building was made possible by a State of North Carolina Capital Fund Grant administered under the Area Health Education Center Program through the University of North Carolina and Charlotte Memorial Hospital and Medical Center.

The six story building provides a two story multi-media center, 14 classrooms, approximately 55 offices for faculty, secretarial personnel and administration personnel. A television studio and photographic laboratory is also provided. A one story annex to the building houses the hospital outpatient clinic reception area.

B. DESIGN PHILOSOPHY

The installation of solar on the project was a retrofit to a project already under construction. The goal was to implement solar space heating and domestic water heating with minimal impact on the existing structure, mechanical systems, and appearance of the overall building design.

C. SOLAR SYSTEM DESIGN OVERVIEW

1. General Description

The solar system is an array of flat plate collectors, underground storage tank, domestic hot water heat exchanger, heating system heat

exchanger, pumps, piping systems, instrumentation, etc. to make a complete and operating system.

The solar system is integrated into the building systems in the following manner: (1) All domestic hot water flows through the domestic hot water heat exchanger prior to entering the building electric water heaters. (2) The heating coil in the solar energy circuit is installed in the building perimeter heating system air unit upstream of the electric heating coil. The control system is integrated to first use the heat available in the solar energy heating coil and then in sequence make up any heating deficit with the building electric heating coil.

The heating and air conditioning systems in the building consist of two basic systems.

The core of the building is served by an all air variable volume constant temperature air system. This system operates in a cooling only mode and is only operational during the occupied hours. All of the outside ventilation air requirements are introduced through this system and thereby, the ventilation load is not imposed upon the building as a heating tax.

The exterior perimeter of the building is served by a constant volume, variable temperature heating and cooling system. This is the system into which the solar system was integrated.

Solarization was not included in the original building concept. Site orientation was conducted with primary consideration for conventional parameters such as topography and surrounding structures. The superlative insulative characteristics of this multi-story 65,000 sq. ft. structure, coupled with the selection of superior solar components and the judicious

placement of solar collectors, has negated an apparent penalty in overall solar efficiency resulting from a less than optimum orientation of the building with respect to solar accumulation.

The solar heating and domestic hot water system consists of 171 General Electric Model P5 collectors, roof mounted in two arrays. Net collector area totals 4,020 sq. ft. A water/ethylene glycol antifreeze solution is circulated through the collectors to a heat exchanger located in a lower level equipment area. Heated water is then supplied primarily to a heating coil in the perimeter air handler or to the 6,000 gallon thermal energy storage (TES) tank, also located in a lower level equipment area. Domestic hot water is provided through a secondary heat exchanger and augmented by 12 KW electrical resistance heaters in each of three manifolded 125 gallon hot water tanks.

The schematic shown in Figure C.1-1 reflects the system concept and Figure C.1-2 shows the proposed solar collector arrays.

A flexible control system is provided for the solar energy system to enable several operating modes. Control and modulating valves were provided and integrated with the existing system, for use with manual and automatic controls to regulate solar supplied heating. The basic control functions will be operated from a self-contained panel located in the building penthouse. The primary operating mode is automatic with overview monitoring by building facilities personnel.

The instrumentation system provides data monitoring and recording for evaluation of system performance and for correlation of predicted to real time data. The instrumentation console will also be located in the penthouse.

A dedicated solar demonstration and viewing room was added to the penthouse of teh AHEC building for holding professional and public observations.

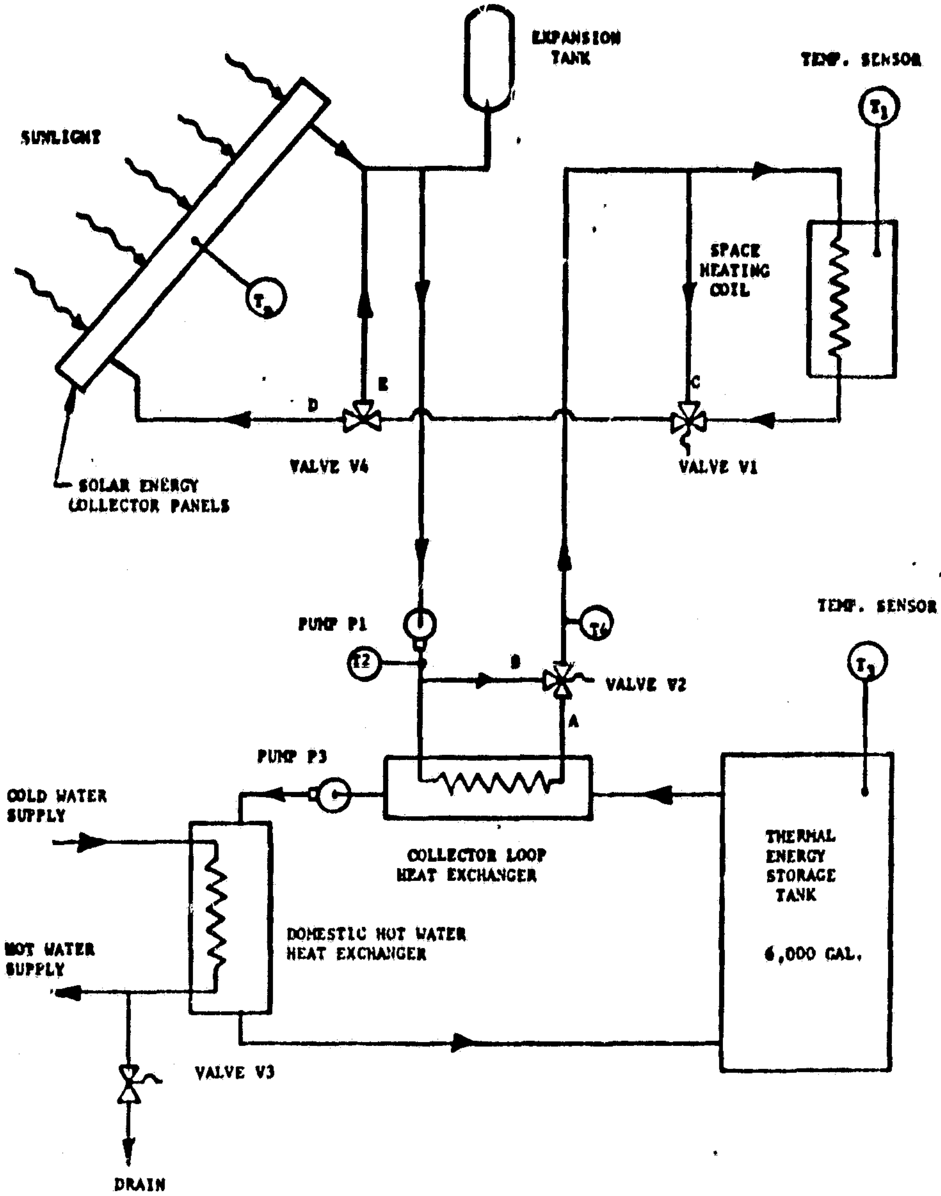

FIGURE C.1-1 AHEC SOLAR HEATING SYSTEM SCHEMATIC

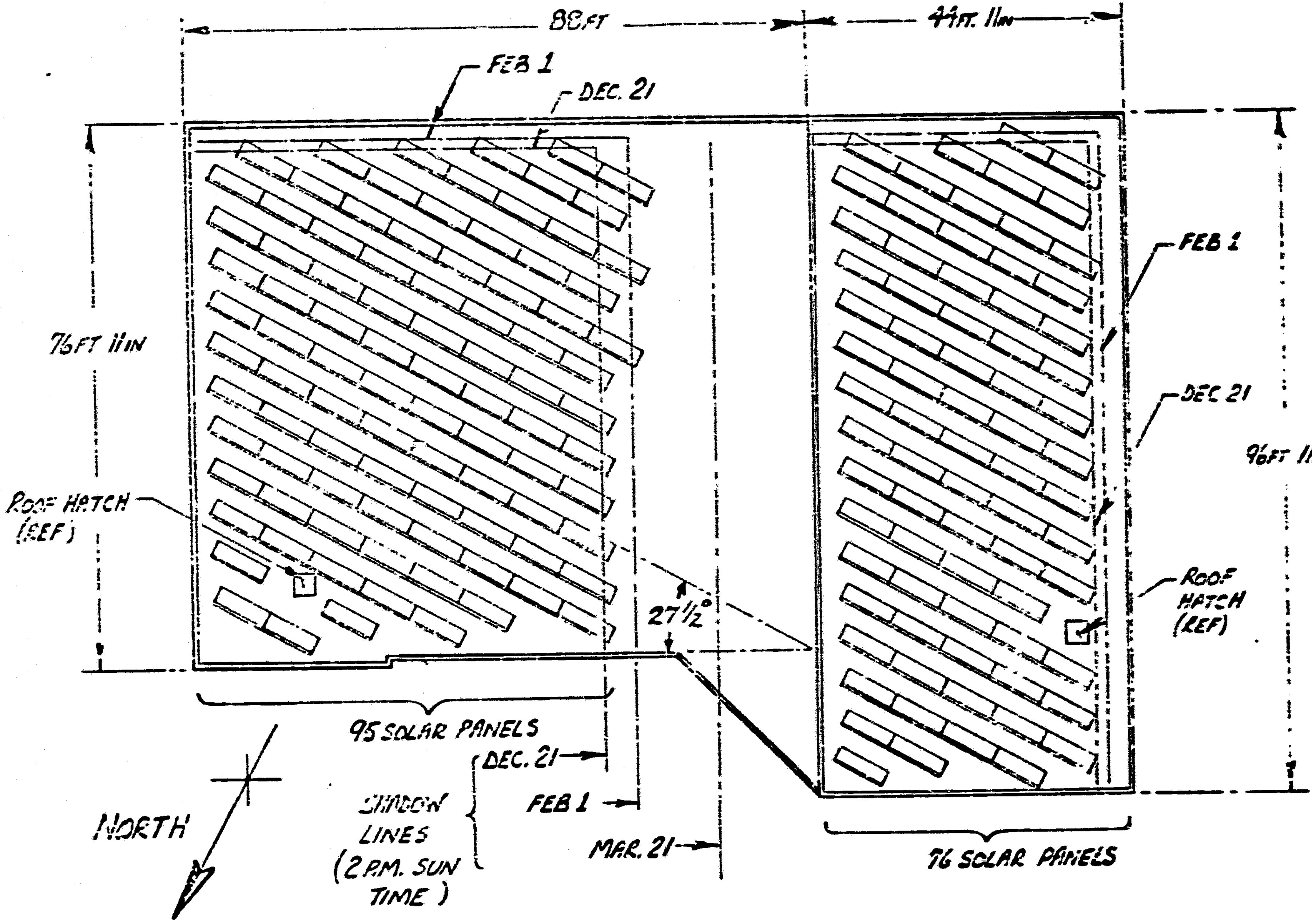

FIGURE C.1-2 AHEC - SOLAR COLLECTOR ARRAY

D. SOLAR COMPONENT SELECTION PROCESS

Using HCC III, an analysis program for the determination of peak heating and cooling loads by APEC (Automated Procedures for Engineering Consultants), the cooling and heating loads for the building were determined. The hot water demand and profiles for the builidng were based on ASHRAE data. The results of the analysis are shown in Figures 1 and 2.

Modeling the characterization of the AHEC building was performed utilizing General Electric's Building Transient Thermal Loads (BTTC) Program. The corresponding parametric analysis was developed by General Electric's Solar Energy System Simulation (SESS) Program.

Conclusions resulting from the analysis are as follows:

1. Solar system efficiency, using a TES minimum temperature (T_{min}) of 105°F is predicted to be 30.3% for space heating and 78.6% for domestic hot water - a total annual of 45.8%.

   With a T_{min} of 80°F, the total annual solar contribution would be increased to approximately 52.5%.

   We recommend a 5° activation range for the TES pump - on at 85°F and off at 80°F.

2. Collector tilt should be changed from 50° to 35° to minimize collector shadowing.
3. Storage volume is confirmed at 6,000 gallons.
4. Proposed 4" coated urethane TES insulation is confirmed.
5. The addition of a second collector cover will result in a performance improvement of only 4% and is, therefore, not recommended.

The descriptions of the enclosed graphs of the study results are as follows:

The building usage schedules, shown in Figure 1, reflect FWA inputs used in determining space heat loads. Monthly space and hot water loads are shown in Figure 2.

The effect of varying TES tank minimum temperature is shown in Figure 3. By allowing the TES tank to operate at lower tamperatures, it is possible to utilize more of the stored energy, particularly for space heating which is the dominant load, and thereby improve the overall solar energy system performance. For the most part, the solar energy is used to preheat the circulated air and cold water supply, with conventional energy providing the deficit.

Two conditions of TES tank minimum were evaluated - results are shown in Figures 4 through 13: $T_{min} = 80^oF$ (Figures 4 through 8); $T_{min} = 105^oF$ (Figures 9 through 13). For the design, it is recommended that the 80^oF condition be used with a 5^oF dead bank (i.e., the pump in the TES load loop would be turned off when the TES temperature = 80^oF and would not turn on again until the TES temperature = 85^oF).

The effect of collector tilt angle on solar energy system performance is shown in Figures 4 and 9. Notice that peak performance can be realized at 45^o - 50^o tilt when row-to-row collector shading is eliminated. This result is consistent with the rule of thumb that optimum tilt for heating applications occurs at an angle equal to the latitude plus 15^o. Domestic hot water demand tends to reduce the optimum angle somewhat. When the design spacing (panel width = 1.6) is implemented, the shading at the higher tilt angles become significant and results in reduced performance. The recommended tilt angle is 35^o.

The performance of the solar energy system is shown in Figures 5 and 10 as a function of collector area. The available roof area and the design spacing between rows of collectors constrain the number of collectors to 171 (3,950 FT^2). For the T_{min} = 80°F condition, 52.5% of the total load is supplied by solar, with 39.5% contributed to space heating and 78.6% to domestic hot water loads. Also, as shown in Figures 5 and 10, the performance of the FP-1 collector can be enhanced 4% to 6% by addition of a second cover.

The effect of varying the TES tank capacity was evaluated over the range 4,000 to 8,000 gallons and the performance is shown in Figures 6 and 11. Beyond 6,000 gallons, the performance curve is relatively flat. Therefore, 6,000 gallons was selected.

The TES tank should be insulated with a material having a minimum thermal conductivity of .3 $\frac{BTU\text{-}IN}{HR\text{-}FT^2\text{-}^oF}$ as measured at a mean temperature of 200°F. The effect of varying insulation thickness on system performance is shown in Figures 7 and 12. A thickness of 4" was selected.

As a result of this analytical study, the design features of the solar energy system have been selected and are summarized below:

Collector Area (Net)	3,950 FT^2
Collector Tilt	35°
TES Tank Capacity	6,000 Gal.
TES Minimum Temperature	80°F
TES Insulation	4" Coated Urethane or Equivalent

If the total load were increased by a factor of 1.5, the overall performance would be reduced to 42.8%; if the total load were doubled, the performance would be reduced to 37.8% (for T_{min} = 80°F as shown in Figure 8). The corresponding effect of varying load for a T_{min} = 105° is shown in Figure 13.

AREA HEALTH AND EDUCATION CENTER
BUILDING USEAGE SCHEDULES

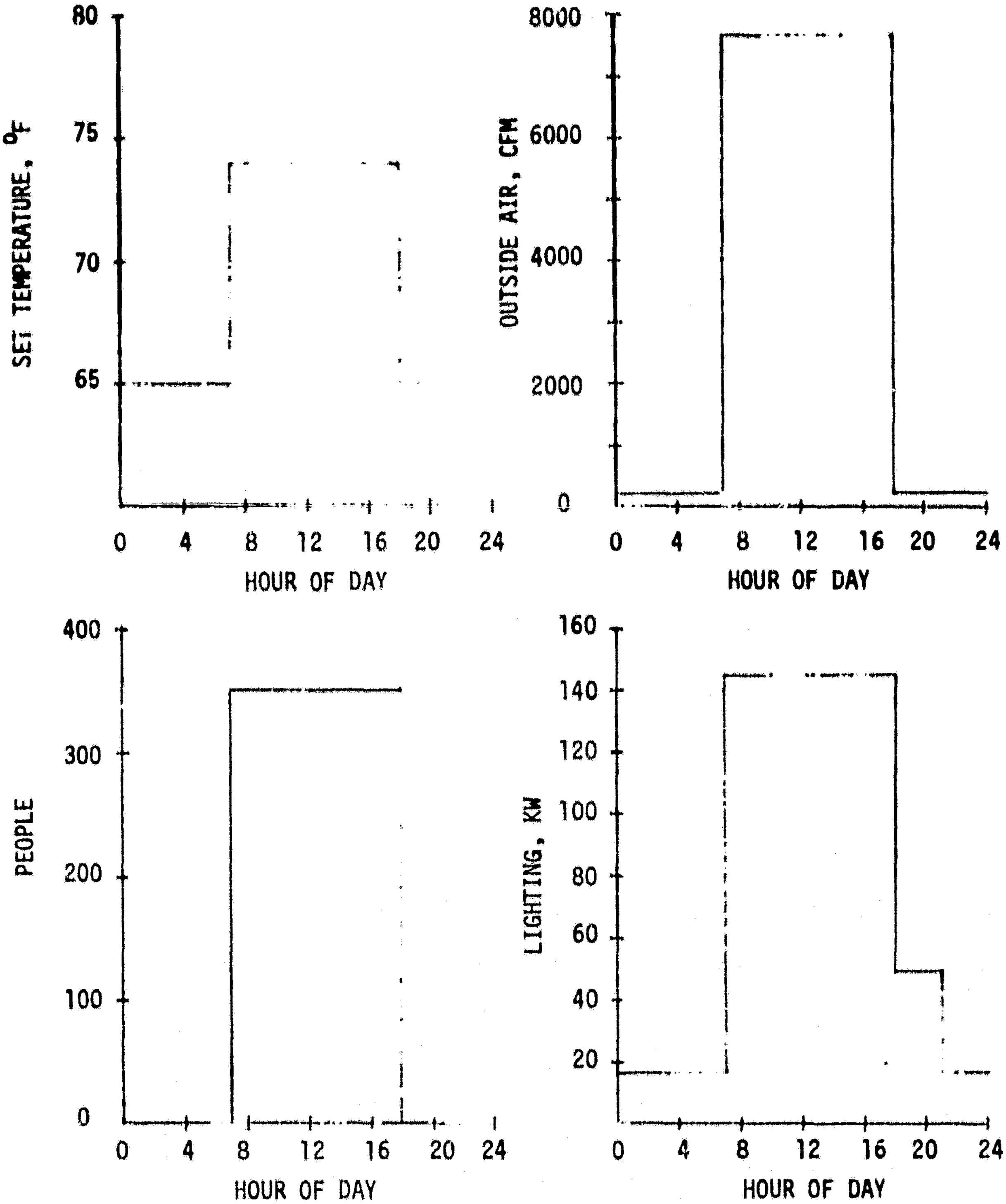

FIGURE 1

AREA HEALTH AND EDUCATION CENTER

MONTHLY LOADS PROFILE

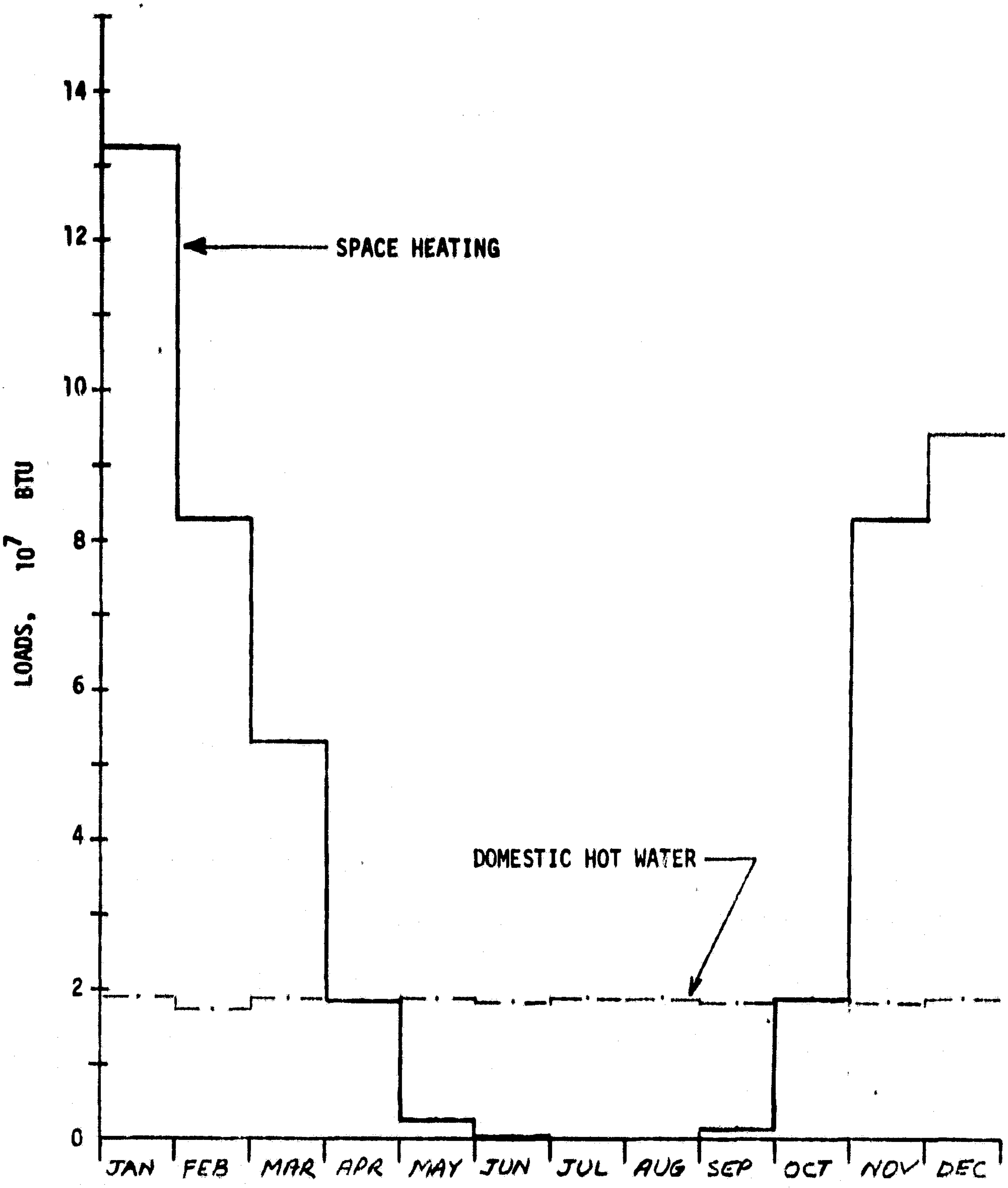

FIGURE 2

AREA HEALTH EDUCATION CENTER

SUMMARY OF ANNUAL BUILDING LOADS

ZONE		SPACE HEAT LOAD, MMBTU
1		71.0
2		18.1
3		25.9
4		6.0
5		6.5
6		358.6
	SPACE TOTAL	486.6
	DOMESTIC HOT WATER TOTAL	222.6
	GRAND TOTAL	709.2

FIGURE 2-1

SOLAR ENERGY SYSTEM PERFORMANCE AS A FUNCTION OF TES TANK MINIMUM TEMPERATURES.

NOTES

1. COLLECTOR AREA = 3950 FT^2
2. TES TANK CAPACITY = 6,000 GAL.
3. TES TANK INSUL. THICK. = 4" ($K = .3 \frac{BTU\text{-}in}{HR\text{-}FT^2\text{-}{}^oF}$)
4. COLLECTOR TILT = 35^o

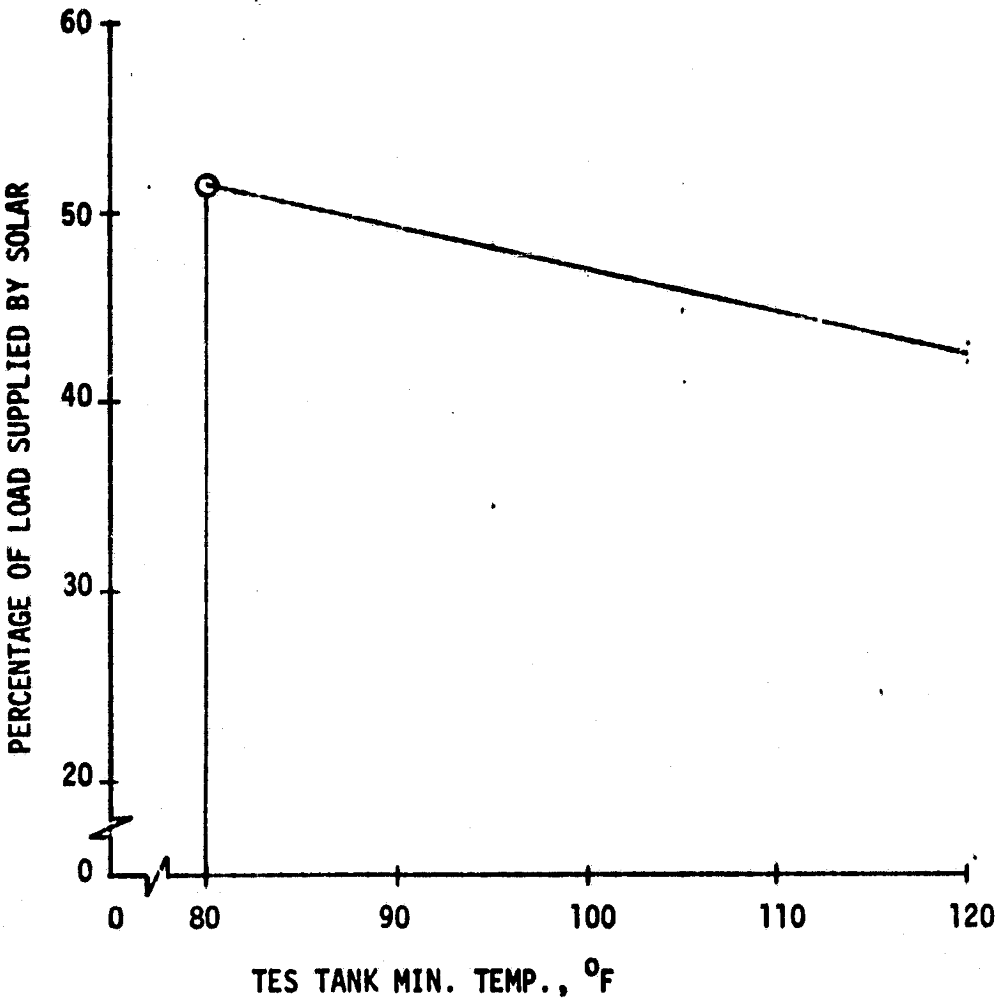

FIGURE 3

AREA HEALTH EDUCATION CENTER

SOLAR ENERGY SYSTEM PERFORMANCE AS A FUNCTION OF COLLECTOR TILT

NOTES:

1. COLLECTOR AREA = 3950 FT^2
2. TES TANK CAPACITY = 6000 GAL.
3. TES TANK MIN. TEMP. = 80^oF
4. TES TANK INSUL. THICK. = 4" ($K = .3 \frac{BTU\text{-}IN}{HR\text{-}FT^2\text{-}^oF}$)
5. - - - - -SHADOWING NOT INCLUDED
   ———SHADOWING INCLUDED

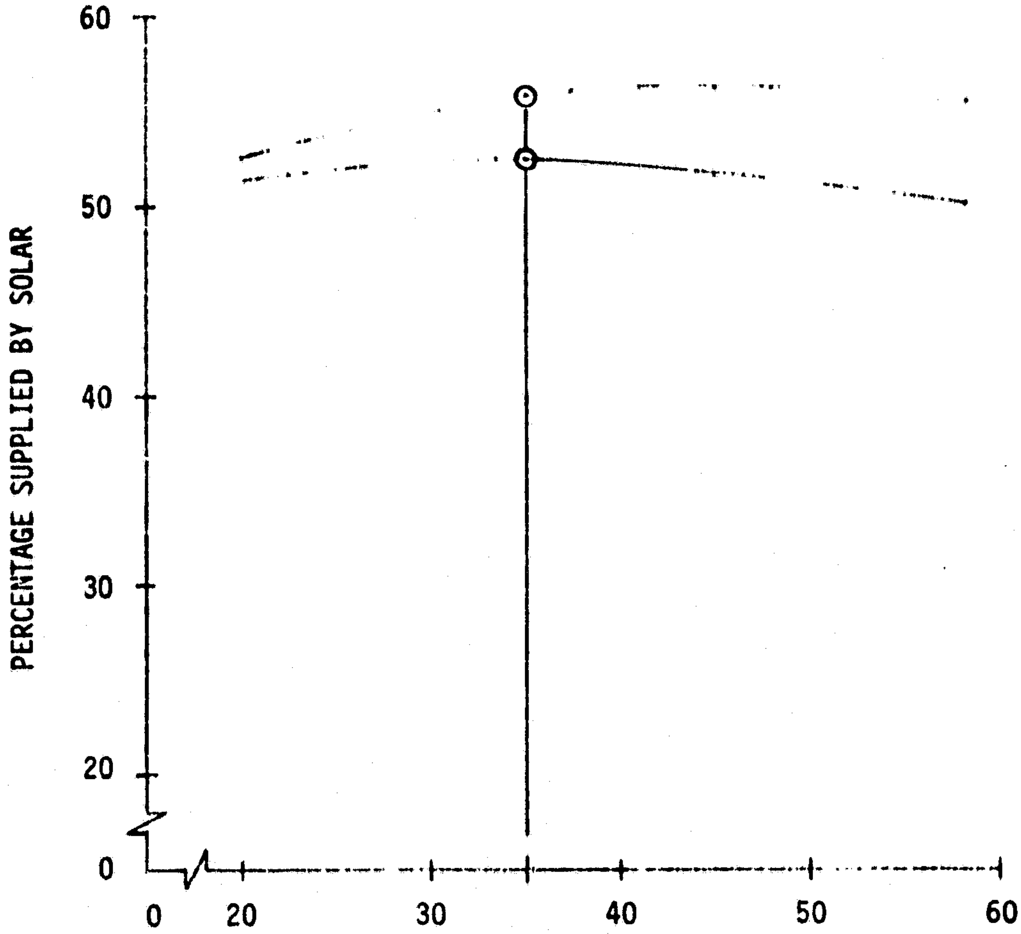

FIGURE 4

AREA HEALTH EDUCATION CENTER

SOLAR ENERGY SYSTEM PERFORMANCE AS A FUNCTION OF COLLECTOR AREA.

NOTES

1. TES TANK CAPACITY = 6000 GAL.
2. COLLECTOR TILT = 35^{o}
3. TES TANK MIN. TEMP = $80^{o}F$
4. TES TANK INSUL. THICK. = 4" ($K = .3 \frac{BTU\text{-}IN}{HR\text{-}FT^2\text{-}{}^{o}F}$)
5. ——— OVERALL PERFORMANCE
   — · — SPACE HEATING PERFORMANCE
   - - - - DOM. HOT WATER PERFORMANCE
6. THE CURVES REFLECT 1 COVER COLLECTORS. THE SYMBOL ○ REFLECTS 2 covers.

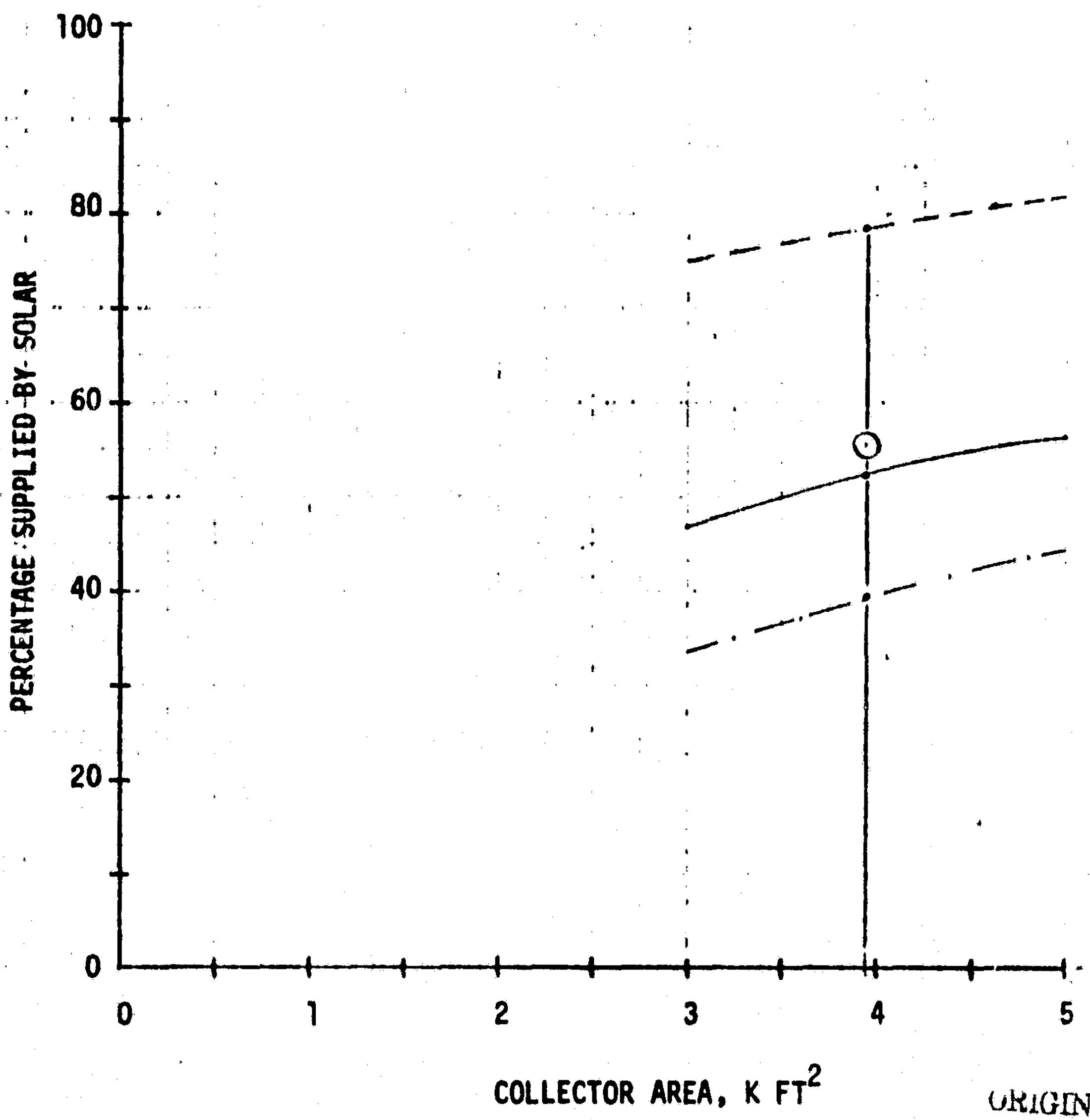

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FIGURE 5

AREA HEALTH EDUCATION CENTER

SOLAR ENERGY SYSTEM PERFORMANCE AS A FUNCTION OF TANK CAPACITY.

NOTES

1. COLLECTOR AREA = 3950 FT^2
2. COLLECTOR TILT = 35^o
3. TES TANK MIN. TEMP. = 80^oF
4. TES TANK INSUL. THICK. = 4" (K = .3 $\frac{\text{BTU-IN}}{\text{HR-FT}^2\text{-}^oF}$)
5. ———— OVERALL PERFORMANCE
   — · — SPACE HEATING PERFORMANCE
   - - - - DOMESTIC HOT WATER PERFORMANCE

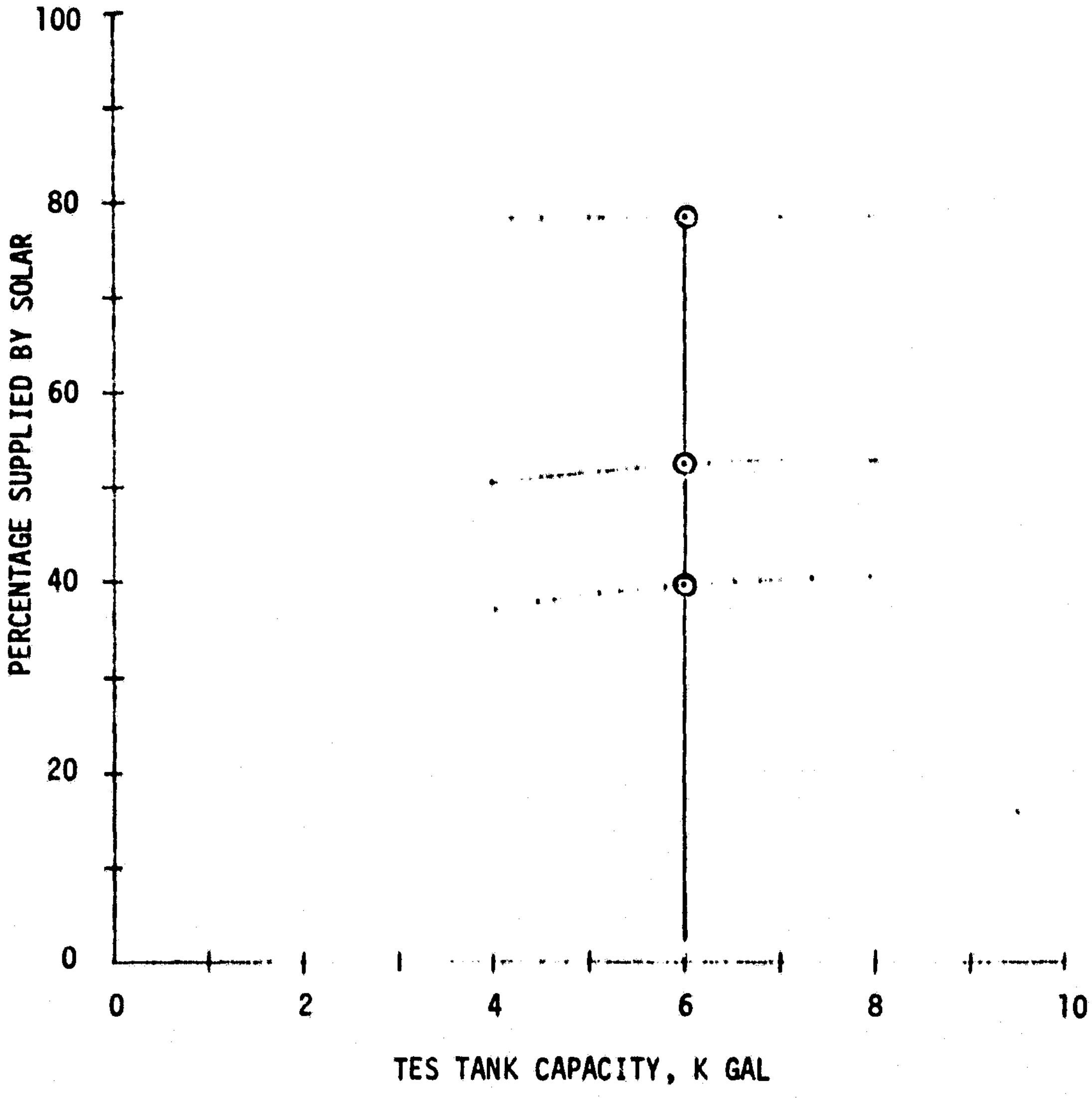

FIGURE 6

SOLAR ENERGY SYSTEM PERFORMANCE AS A FUNCTION OF TES TANK INSULATION THICKNESS.

NOTES:

1. COLLECTOR AREA = 3950 FT^2
2. COLLECTOR TILT = 35^o
3. TES TANK CAPACITY = 6000 GAL.
4. TES TANK MIN. TEMP. = 80^oF
5. TES TANK INSUL. K = .3 $\frac{\text{BTU-IN}}{\text{HR-FT}^2\text{-}^o\text{F}}$

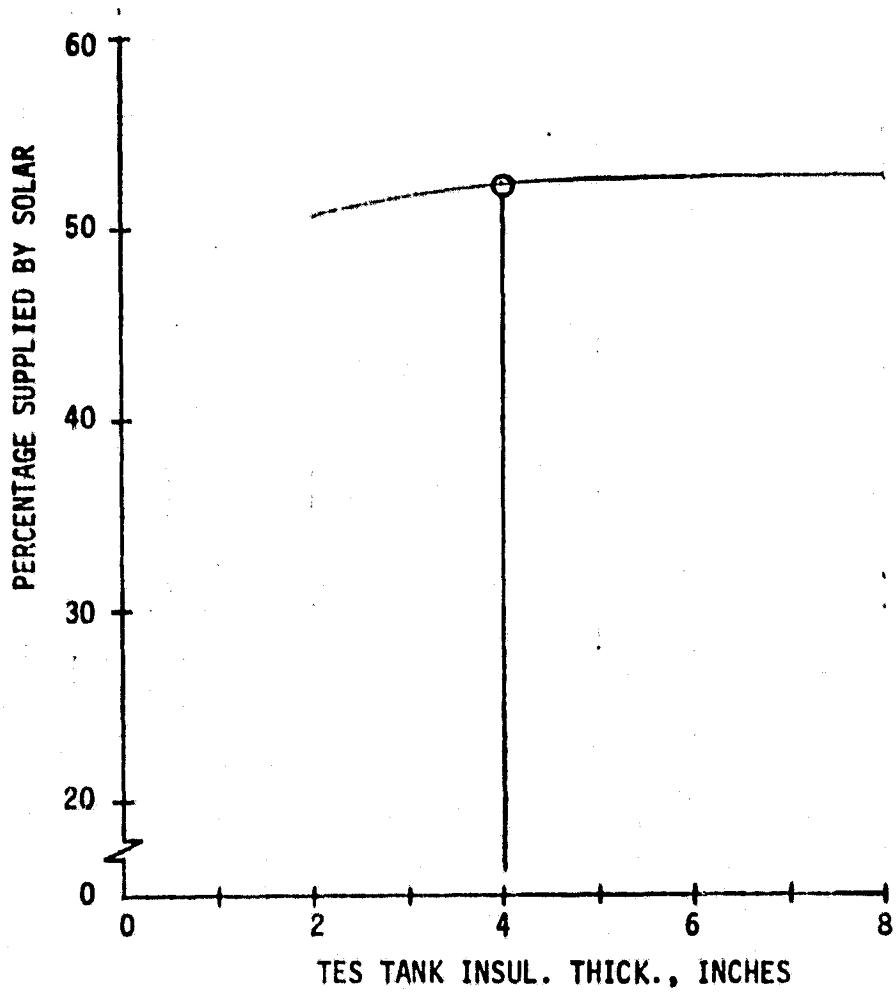

FIGURE 7

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SOLAR ENERGY SYSTEM PERFORMANCE AS A FUNCTION OF LOAD FACTOR.

NOTES

1. COLLECTOR AREA = 3950 FT^2
2. COLLECTOR TILT = 35^o
3. TES TANK CAPACITY = 6000 GAL.
4. TES TANK MIN. TEMP. = 80^o
5. TES TANK INSUL. THICK. = 4" ($K = .3 \frac{BTU\text{-}IN}{HR\text{-}FT^2\text{-}^oF}$)

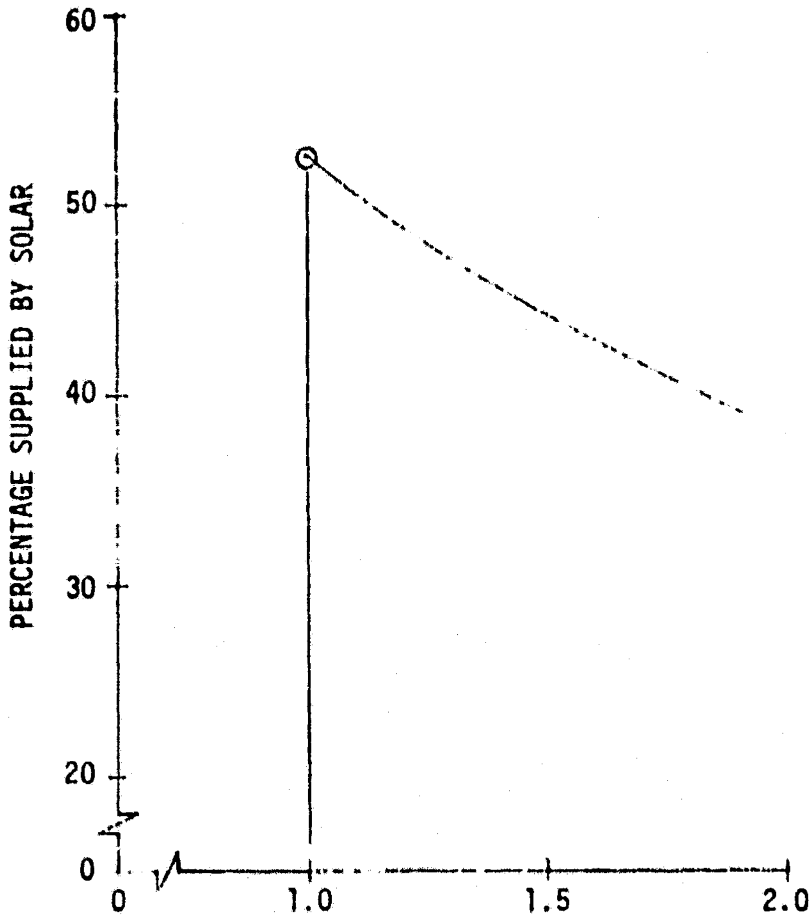


FIGURE 8

AREA HEALTH EDUCATION CENTER

SOLAR ENERGY SYSTEM PERFORMANCE AS A FUNCTION OF COLLECTOR TILT.

NOTES:

1. COLLECTOR AREA = 3950 FT^2
2. TES TANK CAPACITY = 6000 GAL.
3. TES TANK MIN. TEMP. = $105^{o}F$
4. TES TANK INSUL. THICK = 4" ($K = .3 \frac{BTU\text{-}IN}{HR\text{-}FT^2\text{-}^{o}F}$)
5. — — — SHADOWING NOT INCLUDED
   ——— SHADOWING INCLUDED

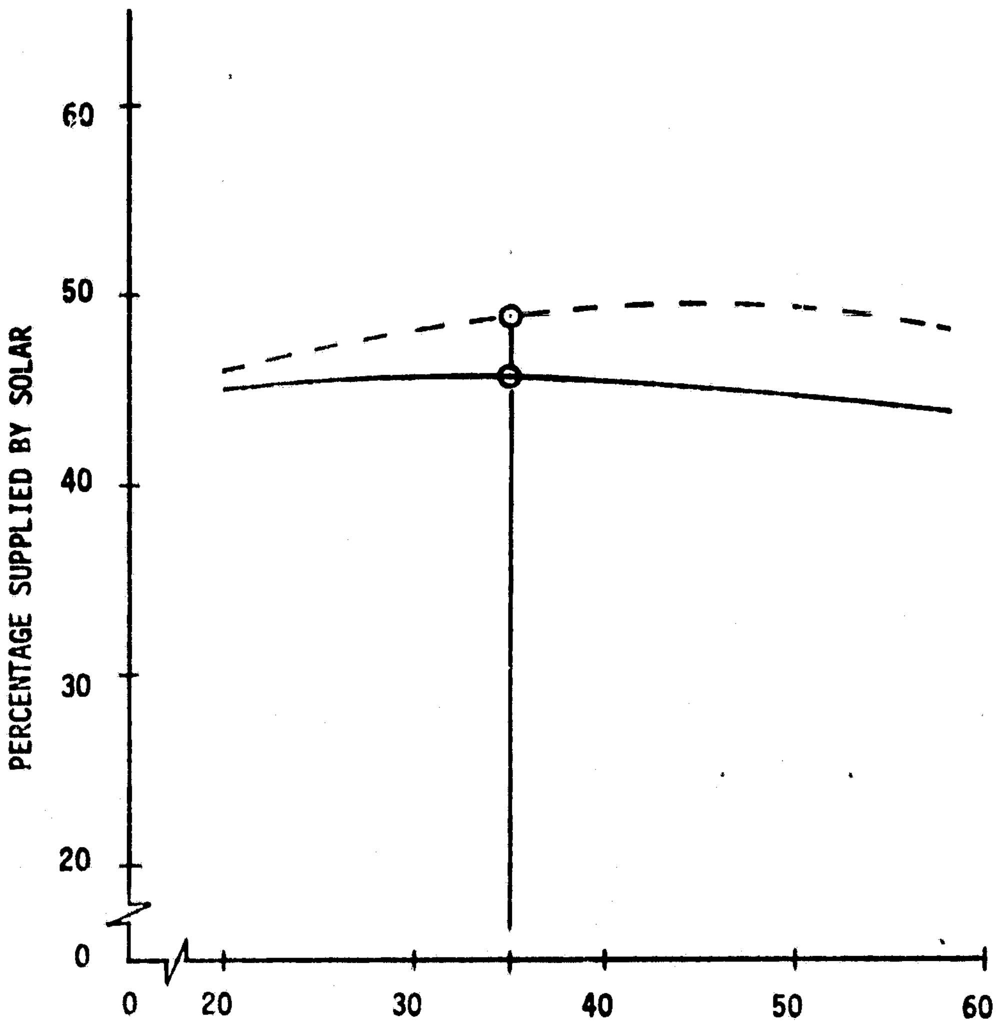


FIGURE 9

AREA HEALTH EDUCATION CENTER

SOLAR ENERGY SYSTEM PERFORMANCE AS A FUNCTION OF COLLECTOR AREA.

NOTES:

1. TES TANK CAPACITY = 6,000 GAL.
2. COLLECTOR TILT = 35°
3. TES TANK MIN. TEMP = 105°F
4. TES TANK INSUL. THICK. = 4" ($K = .3 \frac{BTU\text{-}IN}{HR\text{-}FT^2\text{-}^oF}$)
5. ——— OVERALL PERFORMANCE
   —·— SPACE HEATING PERFORMANCE
   – – – DOM. HOT WATER PERFORMANCE
6. THE CURVES REFLECT 1 COVER COLLECTORS. THE SYMBOL ○ REFLECTS 2 COVERS

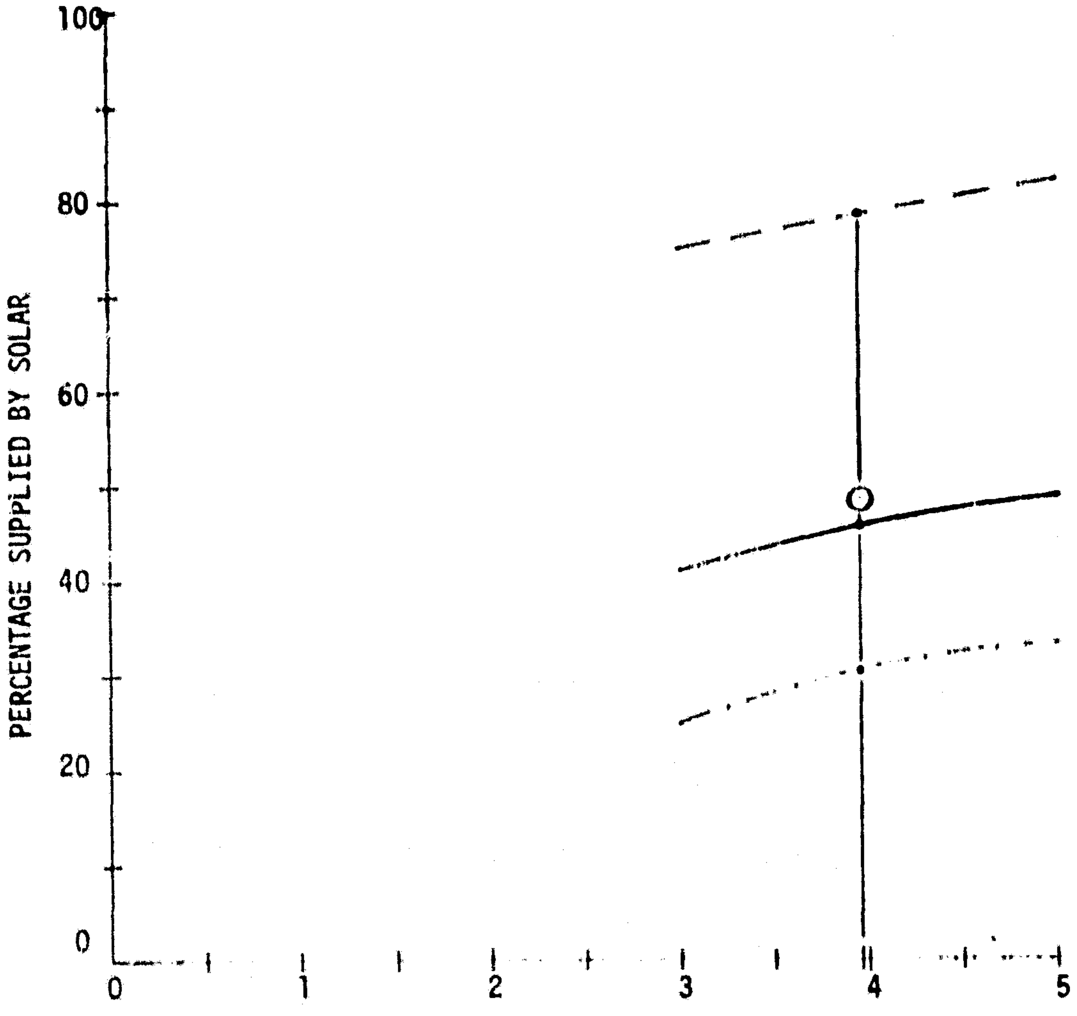


FIGURE 10

AREA HEALTH EDUCATION CENTER

SOLAR ENERGY SYSTEM PERFORMANCE AS A FUNCTION OF TANK CAPACITY.

NOTES:

1. COLLECTOR AREA = 3950 FT^2
2. COLLECTOR TILT = 35^o
3. TES TANK MIN. TEMP. = 105^oF
4. TES TANK INSUL. THICK = 4" ($K = .3 \frac{BTU\text{-}in}{HR\text{-}Ft^2\text{-}^oF}$)
5. ——— OVERALL PERFORMANCE
   —·— SPACE HEATING PERF.
   — —.— DOM HOT WATER PERF.

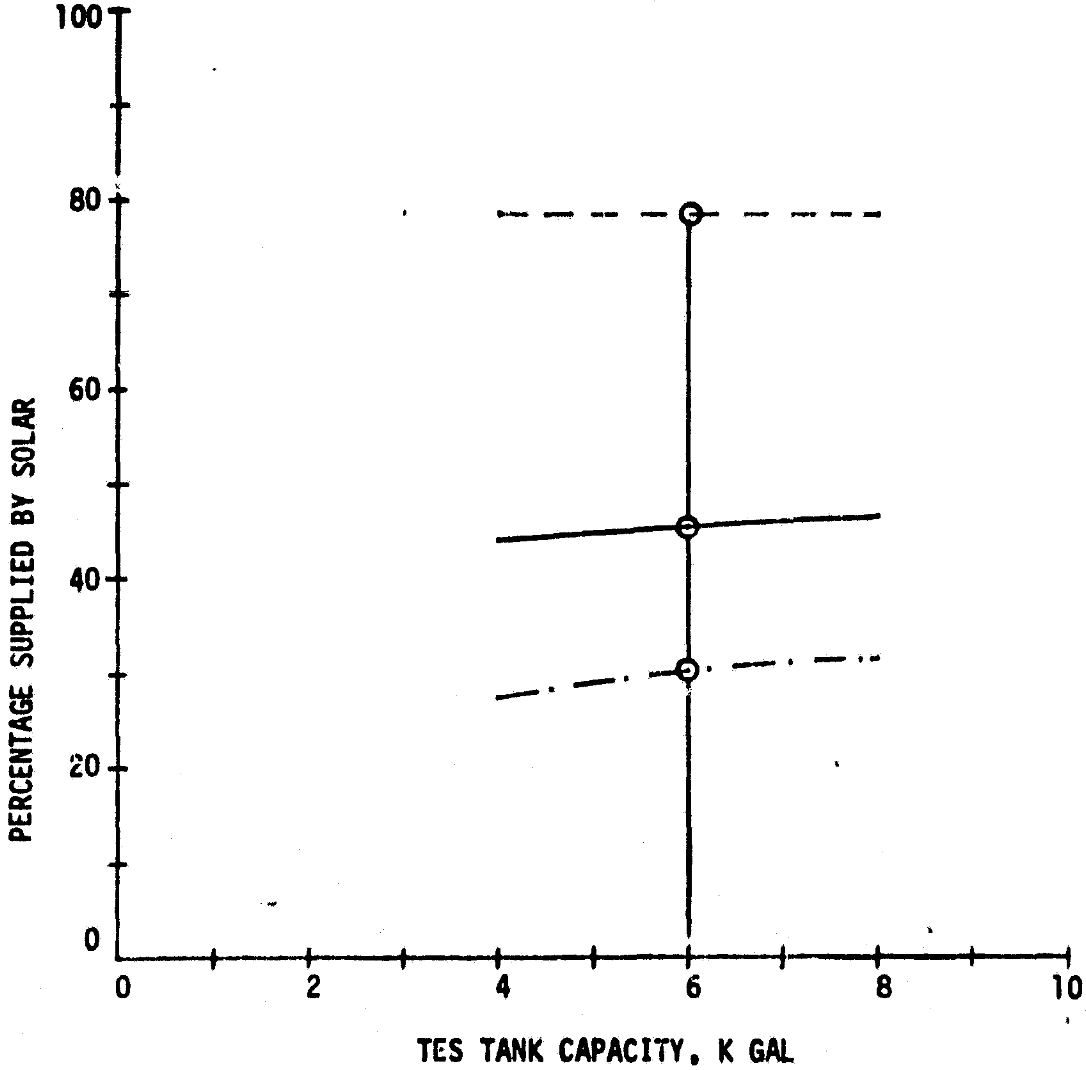


FIGURE 11

AREA HEALTH EDUCATION CENTER

SOLAR ENERGY SYSTEM PERFORMANCE AS A FUNCTION OF TES TANK INSULATION THICKNESS.

NOTES:

1. COLLECTOR AREA = 3950 FT^2
2. COLLECTOR TILT = 35^o
3. TES TANK CAPACITY = 6,000 GAL.
4. TES TANK MIN. TEMP. = 105^oF
5. TES TANK INSUL. K = .3 $\frac{BTU-IN}{HR-FT^2-^oF}$

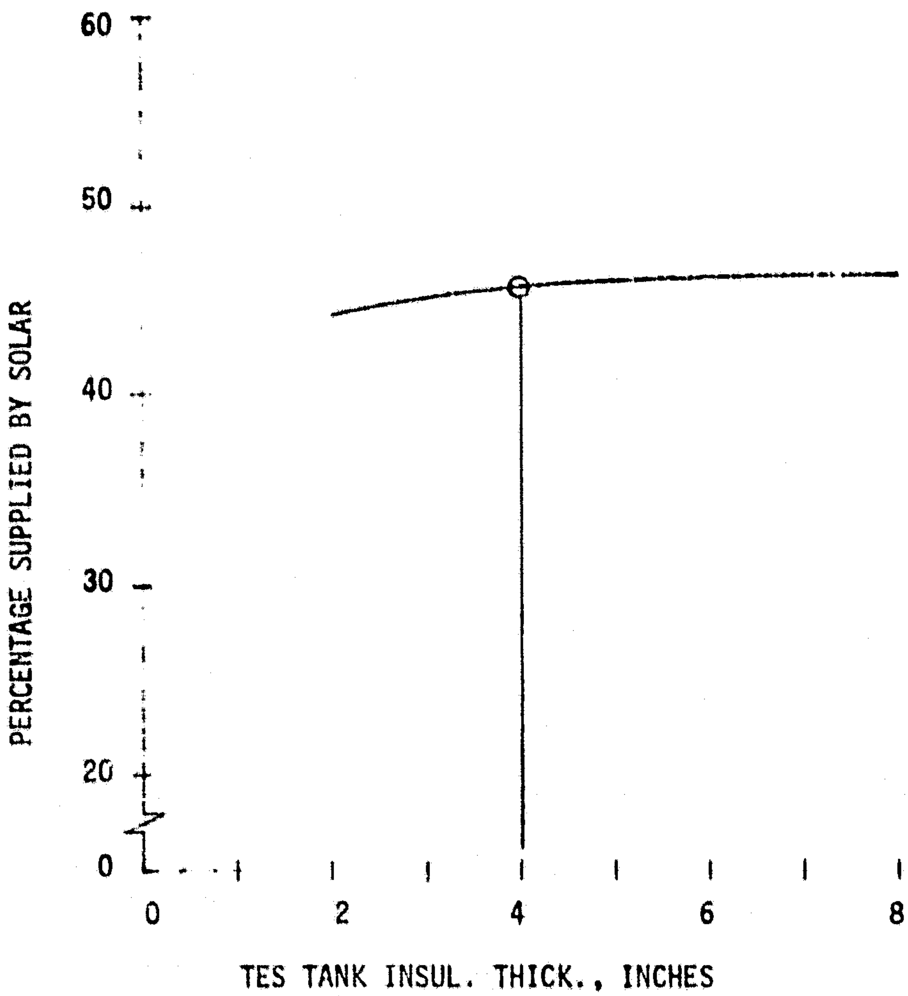


FIGURE 12

AREA HEALTH EDUCATION CENTER

SOLAR ENERGY SYSTEM PERFORMANCE AS A FUNCTION OF LOAD FACTOR.

NOTES:

1. COLLECTOR AREA = 3950 FT^2
2. COLLECTOR TILT = 35°
3. TES TANK CAPACITY = 6,000 GAL.
4. TES TANK MIN. TEMP. = $105^\circ F$
5. TES TANK INSUL. THICK. = 4" ($K = .3 \frac{BTU\text{-}IN}{HR\text{-}FT^2\text{-}^\circ F}$)

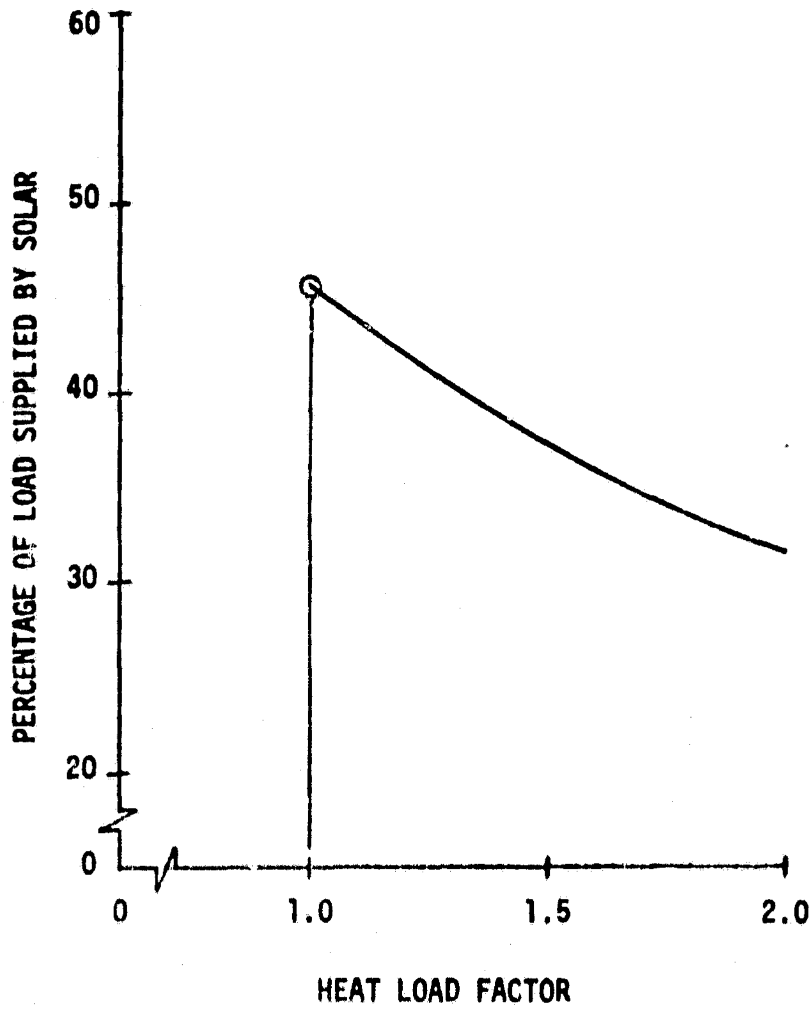


FIGURE 13

In addition to the parametric analysis and modeling which were done for the equipment selection, it was necessary to determine the collector pressure drops with respect to flow and the system temperature balance point, with respect to rejected heat versus collected heat. The results of these studies are shown on Figures 14 and 15, respectively, which follow:

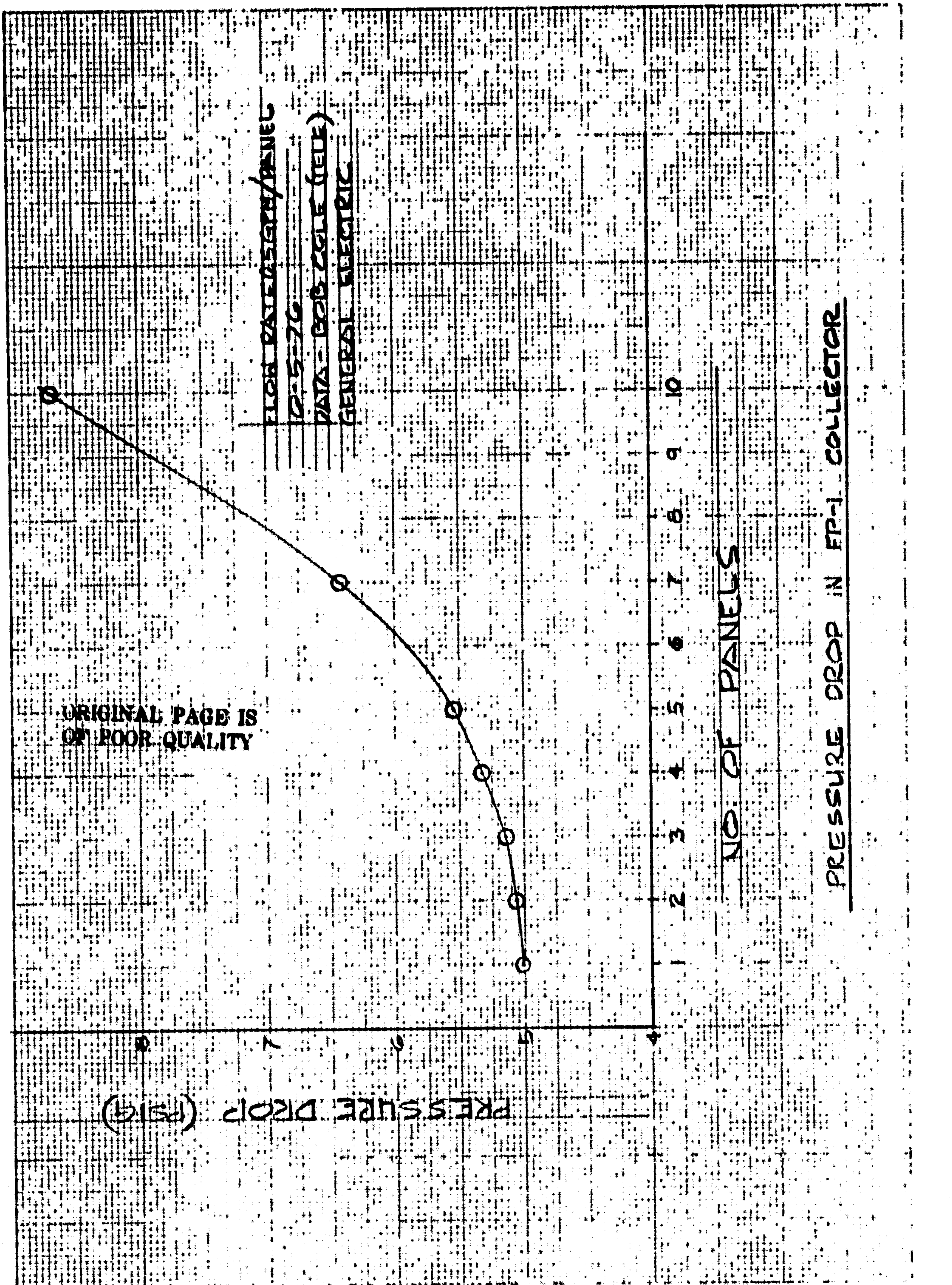

PRESSURE DROP IN FP-1 COLLECTOR
NO. OF PANELS
PRESSURE DROP (PSID)
1 2 3 4 5 6 7 8 9 10
4 5 6 7 8
GENERAL ELECTRIC
ORIGINAL PAGE IS
OF POOR QUALITY

FIGURE 14

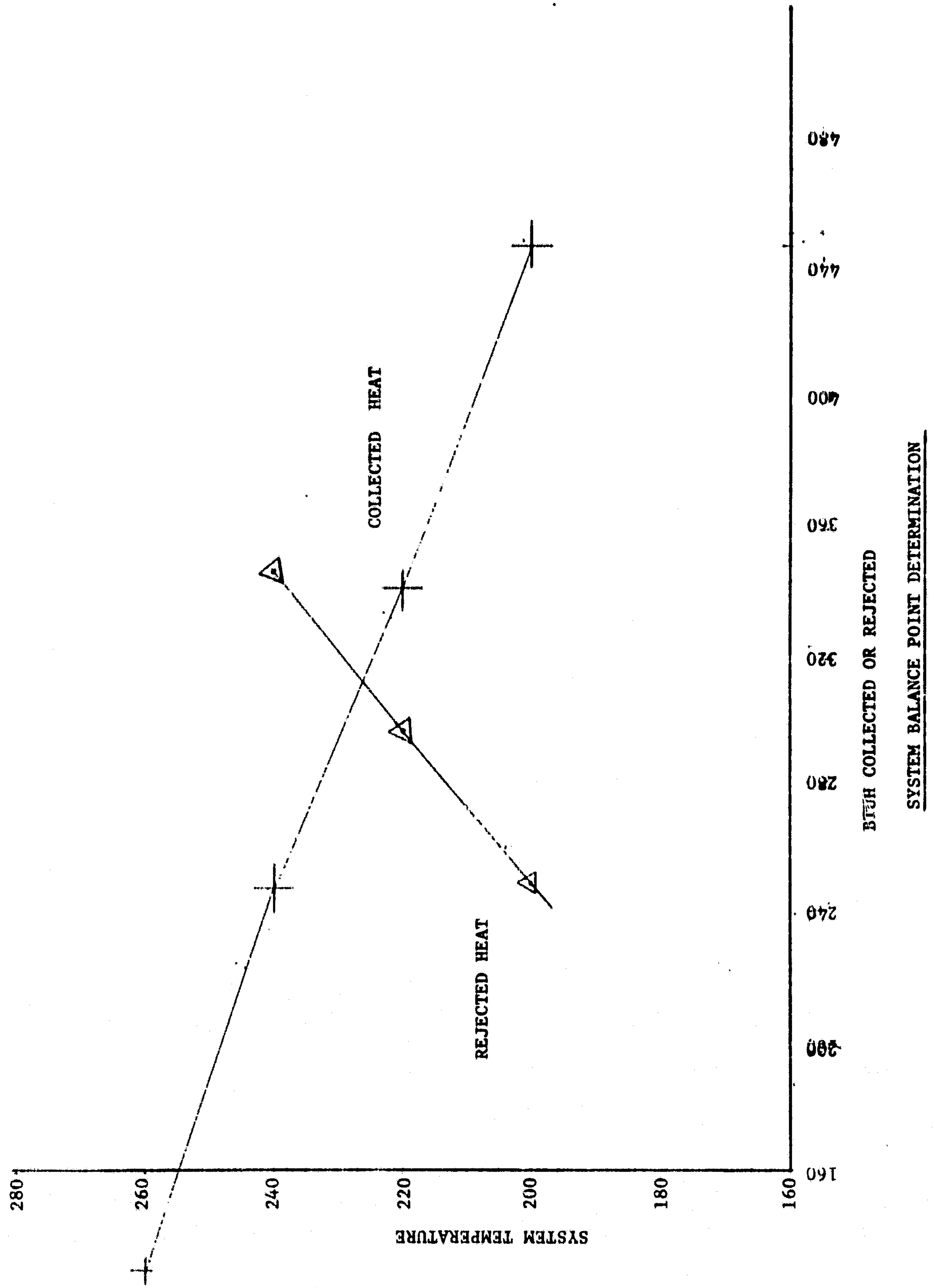

SYSTEM BALANCE POINT DETERMINATION
BTUH COLLECTED OR REJECTED
SYSTEM TEMPERATURE
COLLECTED HEAT
REJECTED HEAT
160
200
240
280
320
360
400
440
480
160
180
200
220
240
260
280

FIGURE 15

II. CONTROL LOGIC AND MODES OF OPERATION

The basic operating philosophy of the control system is the collection and use of solar energy at the lowest usable temperature level because this procedure maximizes the total energy collected per unit collector area over a given time interval. To accomplish this philosophy, the control configuration, shown in schematic form on Figure C.II-1, has been developed. The principal components that comprise the control system, the pumps, valves and temperature sensors, are located on the diagram.

The collector loop system, pump #1, is turned on whenever the collectors are heated above 120°F, the minimum temperature which can transfer useful heat to the building. One objective is to heat the system to operating temperature using collected rather than stored energy.

The energy storage loop is activated, pump #3, when:

(a) The collector loop is running and its temperature is higher than storage temperature. This indicates that storable solar energy is available.

(b) There is a need for space heat and the collector loop is running. This indicates that collected energy can be used immediately for space heating.

(c) There is a need for space heat and the energy storage tank temperature is above 120°F. This indicates that stored energy is available for space heating.

For those cases where more than one operating mode is possible, the control logic selects the mode by operation of the control valves. If space heating can be supplied by the collector loop or the storage tank, comparison of temperatures T2 and T3, shown on Figure E-1, are used to select the setting on valve V2. If T2 is lower than T3, valve V2 bypasses the flow around the storage tank and the heating demand is satisfied by the collectors only. If T3 is lower than T2, then V2 apportions the flow through and around the TES tank to maintain a maximum temperature of 140°F at T4. Limiting the maximum temperature prevents uncomfortably high air temperatures being supplied to the building and/or frequent on-off demands for heat.

Valve V1 modulates the hot fluid flow through the space heating coil to maintain a set point air temperature at T1. In the existing controls system design, T1 is adjustable and can be reset periodically to supply a hotter air temperature as average ambient air temperatures decrease. Automatically reset controls are available so that the T1 set point can be continuously varied to correspond to outside air temperature changes.

Control Parameters

The solar system control parameters are all temperatures as shown on Table C. They are:

(a) Tp - Collector absorber plate temperature

(b) T1 - Heated air temperature at the exit of the solar heating coil and the entrance of the conventional HVAC electric resistance coil.

(c) T2 - Storage/usage loop fluid temperature at the exit of the collector loop heat exchanger (2 control elements).

(d) T3 - Storage tank fluid temperature (3 control elements).

(e) T4 - Storage/usage loop fluid temperature at the entrance to the space heating coil.

Operating Modes

The operating modes are listed in Table C-1 and described with the aid of Figure C.II-1. Control Mode 1 is the case for the shutdown solar system with any space heating demand supplied solely by the conventional HVAC system.

Mode 2 is a collector preheat situation that will occur frequently in the morning hours. As the rising sun starts heating up the collector, the collector pump is turned on when the collector temperature exceeds 120°F. The collected heat is used to raise the collector loop components to operating temperatures.

Mode 3 is a situation where solar heat is available for collection and storage at a time when there is no immediate demand for heat. Valve V2 diverts the entire flow from P1 to the heat exchanger. V1 is set to divert flow through the bypass loop.

In Mode 4, no direct solar energy is avavilable; however, stored solar energy can provide the heating functions. As Table C-1 indicates, Mode 4 occurs when the collector plate temperature is below 120°F and the thermal storage tank temperature is above 120°F. Temperature sensor T1 controls the three-way diverting valve V1 to maintain the air temperature downstream of the space heating coil at an adjustable set point temperature. Mixing valve V2 is controlled by sensor T4 which maintains fluid temperature into the space heating coil at 140°F or some other adjustable set point.

Mode 5 transfers solar energy directly from the collector loop to the space heating coil. This happens when solar energy is available

(thermal switch Tp indicates collector temperature greater than 120°F), but the transferred energy (as measured by the thermistor T2) is lower than storage temperatures. Full flow in the usage loop is directed in the "B" direction (TES bypass) by mising valve V2.

<u>Mode 6</u> is the normal daytime heating operation. Solar energy is available in sufficient quantity to store energy in the thermal storage tank and to heat the building. Valves V1 and V2 again control the collector loop flow. The domestic water heat exchanger is constantly taking energy as needed from the fluid flow into the thermal storage tank. This provides domestic hot water.

<u>Mode 7</u> is a safety operation. When the thermal storage tank temperature rises to 200°F, a thermal switch closes. This energizes valve V3 (open) in the solar water loop. This results in full fluid flow through the heat rejector. Also, valve V2 operates in the "A" direction, diverting all flow around the collector loop heat exchanger. Pump P-1 runs and Pump P-3 is off.

<u>Mode 8</u> is a domestic hot water heating mode in the summer time when space heating is not needed. A timer is used to turn on P-3 during daylight hours, with a cut out if the TES temperature is less than 120°F. In this way, hot water is available on demand. The collector loop is activated independently at any time that Tp exceeds T2.

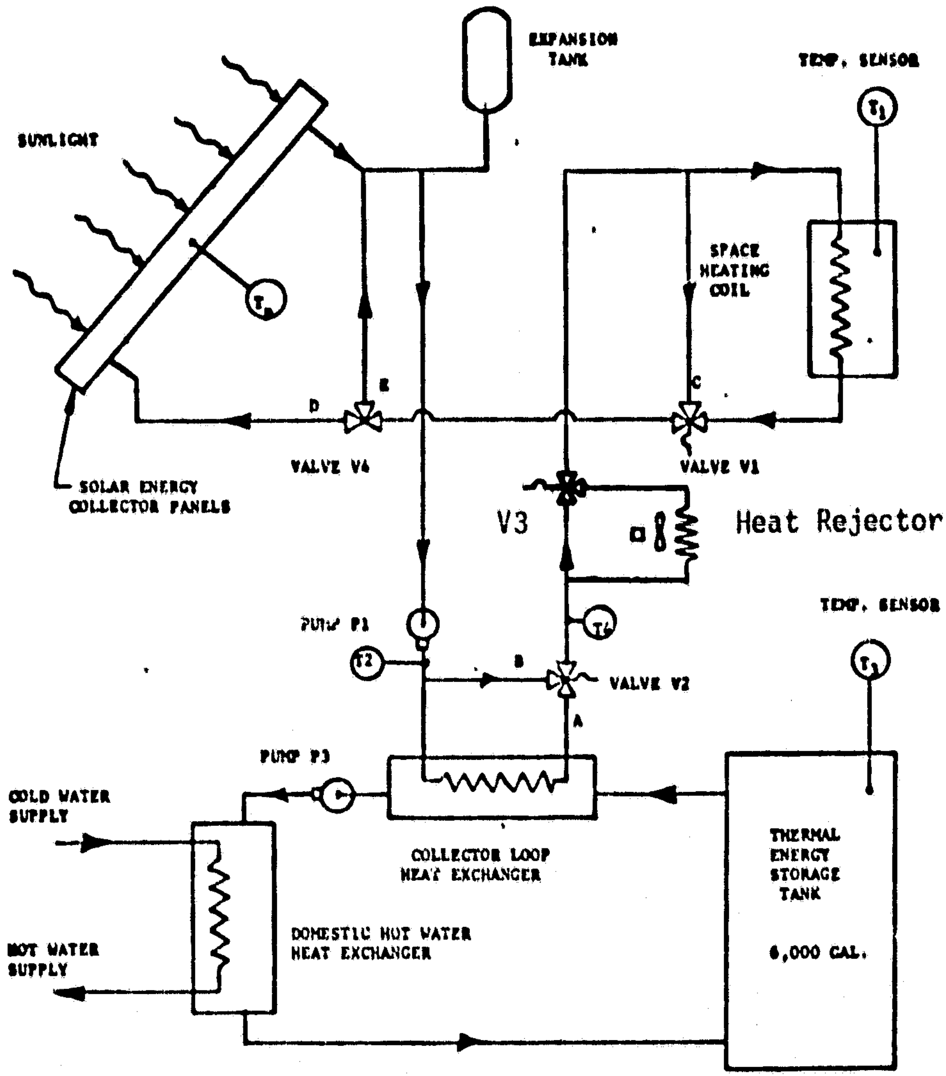


FIGURE C.II-1 AHEC SOLAR HEATING SYSTEM SCHEMATIC

TABLE C-1 AHEC SOLAR HEATING SYSTEM OPERATING MODES

MODE	CONDITIONS	COLLECTOR LOOP PUMP (P1)	TES LOOP PUMP (P3)	VALVE V1	VALVE V2	VALVE V3	VALVE V4
1. NO SOLAR HEAT, SOLAR SYSTEM OFF	COLLECTOR TEMPERATURE BELOW 120°F TES TEMPERATURE BELOW 120°F	OFF	OFF	"C" FLOW	"B" FLOW	CLOSED	"D" FLOW
2. COLLECTOR LOOP PREHEAT	COLLECTOR TEMPERATURE ABOVE 120°F. TES TEMPERATURE ABOVE COLLECTOR TEMPERATURE. NO DEMAND FOR SPACE HEATING.	ON	OFF	"C" FLOW	"B" FLOW	CLOSED	"D" FLOW
3. COLLECTING AND STORING AND SOLAR HEAT.	COLLECTOR TEMPERATURE ABOVE 120°F AND ABOVE TES TEMPERATURE. NO DEMAND FOR SPACE HEATING.	ON	ON	"C" FLOW	"A" FLOW	CLOSED	"D" FLOW
4. SUPPLYING SPACE HEAT FROM STORAGE	COLLECTOR TEMPERATURE BELOW 120°F. TES TEMPERATURE ABOVE 120°F. DEMAND FOR SPACE HEATING.	ON	ON	MODULATED ON T1	MODULATED ON T4	CLOSED	"E" FLOW
5. SUPPLYING SPACE HEAT FROM COLLECTOR.	COLLECTOR TEMPERATURE ABOVE 120°F. TES TEMPERATURE ABOVE TEMPERATURE T2. DEMAND FOR SPACE HEATING.	OFF	ON	MODULATED ON T1	"B" FLOW	CLOSED	"D" FLOW
6. COLLECTORS SUPPLYING BOTH SPACE HEAT AND STORABLE ENERGY	TEMPERATURE T2 ABOVE 130°F AND ABOVE TES TEMPERATURE. COLLECTOR TEMPERATURE ABOVE 120°F. DEMAND FOR SPACE HEATING.	ON	ON	MODULATED ON T1	MODULATED ON T4	CLOSED	"D" FLOW
7. DUMPING EXCESS SOLAR ENERGY	TES TEMPERATURE ABOVE 200 °F	ON	OFF	"C" FLOW	"B" FLOW	"C" FLOW	"D" FLOW
8. HOT WATER HEATING - SUMMER OPERATION	TES TEMPERATURE ABOVE 120°F	OFF/ON	ON	"C" FLOW	"A" FLOW	CLOSED	"D" FLOW

III. ACCEPTANCE TEST PLAN

As the system was being built, several leak tests were performed on individual sections of the piping and the storage tank. Prior to actual starting of the system, the entire system was checked for leaks under pressure. After testing, system was filled with the glycol mixture and the slow process of eliminating the air for the system was accomplished.

Manual balancing of all circuits was accomplished by setting the individual balance cocks on each collector circuit to equalize the flow through each collector. The total system flow was checked by two methods, the pump curve and the main system flow control device (B & G circuit setters). At this time, it was found that the system flow was approximately 100 GPM rather than 85 GPM as designed. The pump discharge valve was adjusted to reduce the flow.

Each temperature sensor set point was checked, first with a mercury thermometer and against a pneumatic output chart for the device. The operation of each valve was verified as thermostats were manually adjusted to simulate each mode of operation.

Further checks were made with the government's Site Data Acquisition System and the on-site monitor.

Observation of the system under automatic control was used to check morning start-up time and night shut down times, storage times, heating time, and pump operation. Minor adjustments of all set points were required to improve the actual operation. One sensor was found defective on the solar array and was replaced.

IV. EQUIPMENT SCHEDULE

SOLAR COLLECTORS

171 General Electric Flat Plate Solatron Collectors, Model P-5, with aluminum roll bond absorber panel coated with Alcoa coating 655, minimum absorption 0.9, Emissivity at 100°F is 0.35. Insulation is 2-inch thick foil backed, high temperature, isocyanurate insulation by Celotex Corporation (Techniform Isocyanurate Class 1 general purpose insulation). Cover is 0.060 inch thick polycarbonate sheet, stabilized for UV by General Electric (LEXAN - GE EMPIS Specifications A16B54B2).

STORAGE TANK

6,000 gallons, black steel tank wrapped with 4-inch thick layer of urethane foam insulation in black form, waterproofed with 2 layers of mastic and fiberglass.

Pumps were selected to meet design criteria as follows:

PUMPS

NO.	LOCATION	SERVICE	TYPE	GPM	HEAD	RPM	HP	VOLTAGE	PHASE	STARTER	MFG. & MODEL
P-1	Equipment Rm.	Solar Array	Base Mtd.	85	104	1750	7-½	460	3Ø	Mag.	B&G Series 1510 1½
P-2	Equipment Rm.	Stg. Loop	Inline	85	35	1750	2	450	3Ø	Mag.	B&G Series 60 2"A*

*All Bronze

Heat Exchangers were selected to meet design criteria as follows:

CONVERTERS

NO.	SERVICE	CAPACIATY(MBH)	Tubes						Shell						MFG & MODEL
			Fluid	GPM	EWT	LWT	P.D.	Fouling Factor	Fluid	GPM	EWT	LWT	P.D.	Fouling Factor	
C-1	Collector Loop	700 MBH	Water	85.0	65°F	80°F	10.0'	0.0005	Gylcol	85.0	100°F	85°F	23.0'	0.0005	TACO B10420L
C-2	Domestic H. Wat.	50 MBH	Water	5.0	60°F	140°F	1.0'	0.0005	Water	85.0	160°F	145°F	2.0'	0.0005	TACO B6604LN*

* Brass Tube & Head

Space Heating Coil was selected to meet design criteria as follows:

HEATING COIL												
LOCATION	CAPACITY(MBH)	EWT	EAT	FLUID	GPM	P.D.	CFM (AIR)	P.D. (AIR)	FINS	ROWS	SIZE	MFG & MODEL
Existing AHU#2	700 MBH	$140^{o}F$	$70^{o}F$	50%glycol	85	6.5FT	15,500	0.75"WG	10F./In	4 Rows	36x108	McQuay 5WS

V. PROBLEMS ENCOUNTERED, SOLUTIONS & RECOMMENDATIONS

Initially, everything worked as designed, but as we watched the system operate, it became apparent that several changes should be made to improve the system's operation:

1. During summer operation, when the storage tank reached the maximum design temperature of 200°F, there was a problem with loss of the glycol solution through the pressure relief valve.

   This problem was due to a miscalculation in the expansion tank size, thus creating excessive pressure in the solar collector loop.

   The solution was to increase the expansion tank size to 160 gallons.

2. During the first winter of operation, several of the rubber interconnecting hoses between the solar panels developed leaks at the connection point. Also, a valve on the fresh water fill circuit had been left open. As the glycol leaked out, fresh water diluted the glycol and one section of collectors was damaged.

   Nine collector panels were replaced at this time and the make-up water connection was disconnected and capped to eliminate the possibility of recurrence. A 55 gallon tank and fill pumps were added to allow filling of the circuit with glycol. This tank was also connected to the relief valve so, if any glycol was lost there, it could be recovered.

3. During summer operation, the domestic hot water would be heated to 200 degrees and during the winter, the electric secondary hot water heater would add heat to the solar storage tank.

These problems were related to the hot water recirculation line being piped such that its total flow went through the domestic water heat exchanger. During off-hours of the building, in the summer, the recirculating line would provide heat to the domestic water tanks from the solar storage tank. In the winter, the domestic water heaters would supply heat to the solar storage tank any time the solar tank temperature was below the thermostat setting of the domestic water heaters.

The cure was to relocate the recirculating line downstream of the domestic water heat exchanger.

4. Wet insulation on the underground solar storage tank was also a problem. At the same time water was being lost in the storage loop. The initial thought was that the storage tank was leaking.

   The storage tank was dug up and all insulation was removed. The tank was pressure tested for leaks and none were found. Sprayed-on urethane (waterproof) was reapplied to a thickness of 4 inches and the tank recovered. Sand was found in the pressure relief valve and the leak stopped.

   The wet insulation was ground water resulting from prolonged periods of rain over three weeks. Only the top one-third (1/3) of the insulation was wet.

5. Late starting times for the solar loop pump and periods where the pump ran at night.

   Over a period of three years, the differential controls (pneumatic) had gotten out of adjustment and caused some of the problem. Also, the location of the sensor which turns on the

solar loop pump was in a position in the array which remained shaded early in the morning, thus, a time delay occurred. When it was time for the pump to turn off, the pneumatic controls sensed a differential (any differential) and kept the pump running at night.

The cure to this problem was to install an electronic differential controller on which exact on-off differentials can be set and relocate the starting sensor to a location in the array. These changes did solve both the late starting times and the sporadic running of the solar loop pump at night.

6. The electric duct heater which supplies heat to the building was being energized too early when heat was available from the solar storage tank.

   This problem only occurred after about three years of operation and was traced to a bad circuit in the sequencer installed on the heater and solar coil controls. Replacement of this controller improved the building temperature control and now allows a greater contribution of heat by solar.

7. Warping of solar panels.

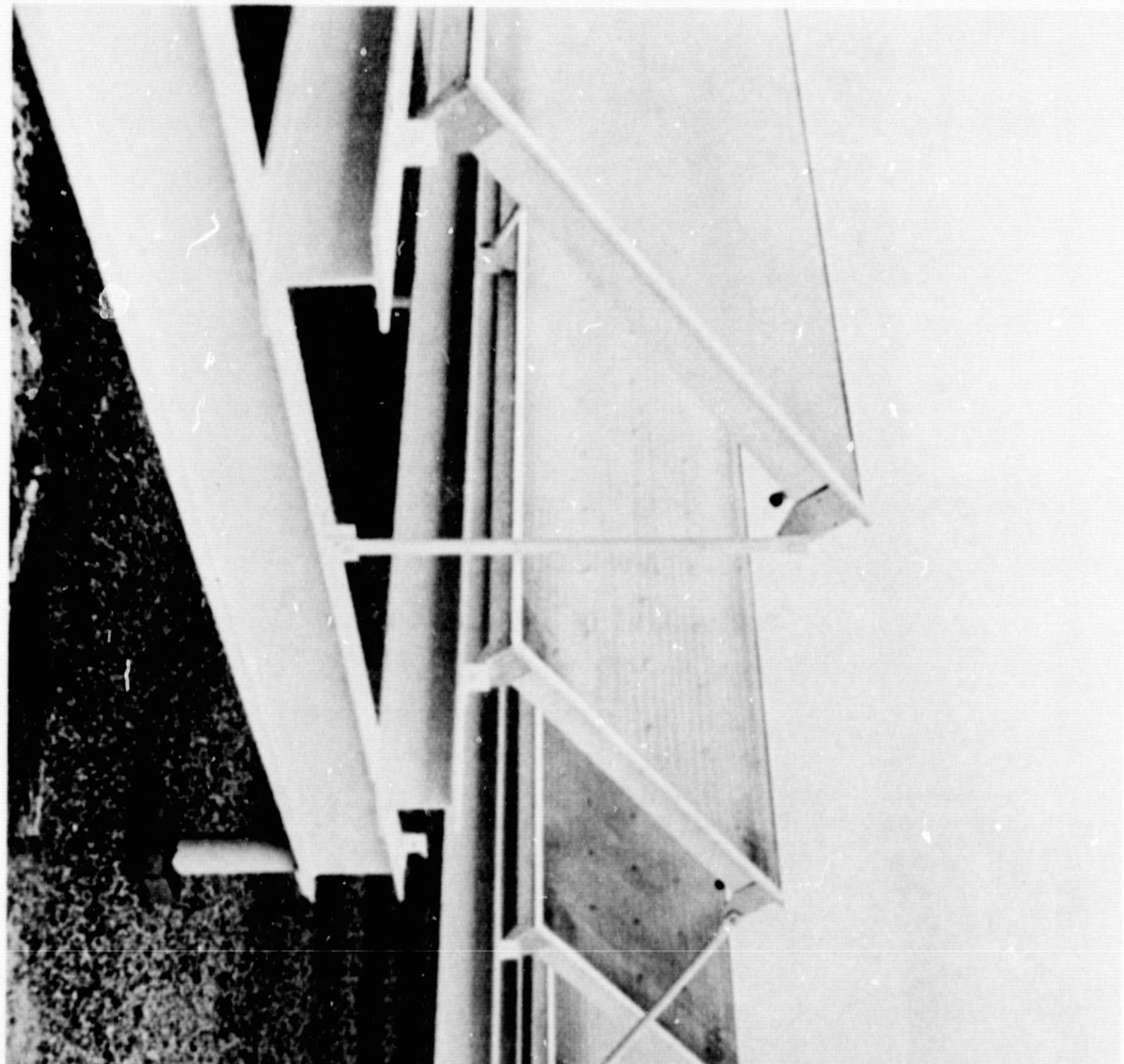
   After one year of operation, we found most of the aluminum panels were warped. The casing size of the panels is not large enough, thus when the panels expand during the summer, the panels are warped when they press against the ends and sides of the casing. The holes in the back of the panel casing are not elongated and during expansion, the pipe connections to the collector are bent. Several of the panels began leaking after this connection was bent. On a couple of the panels, the bending

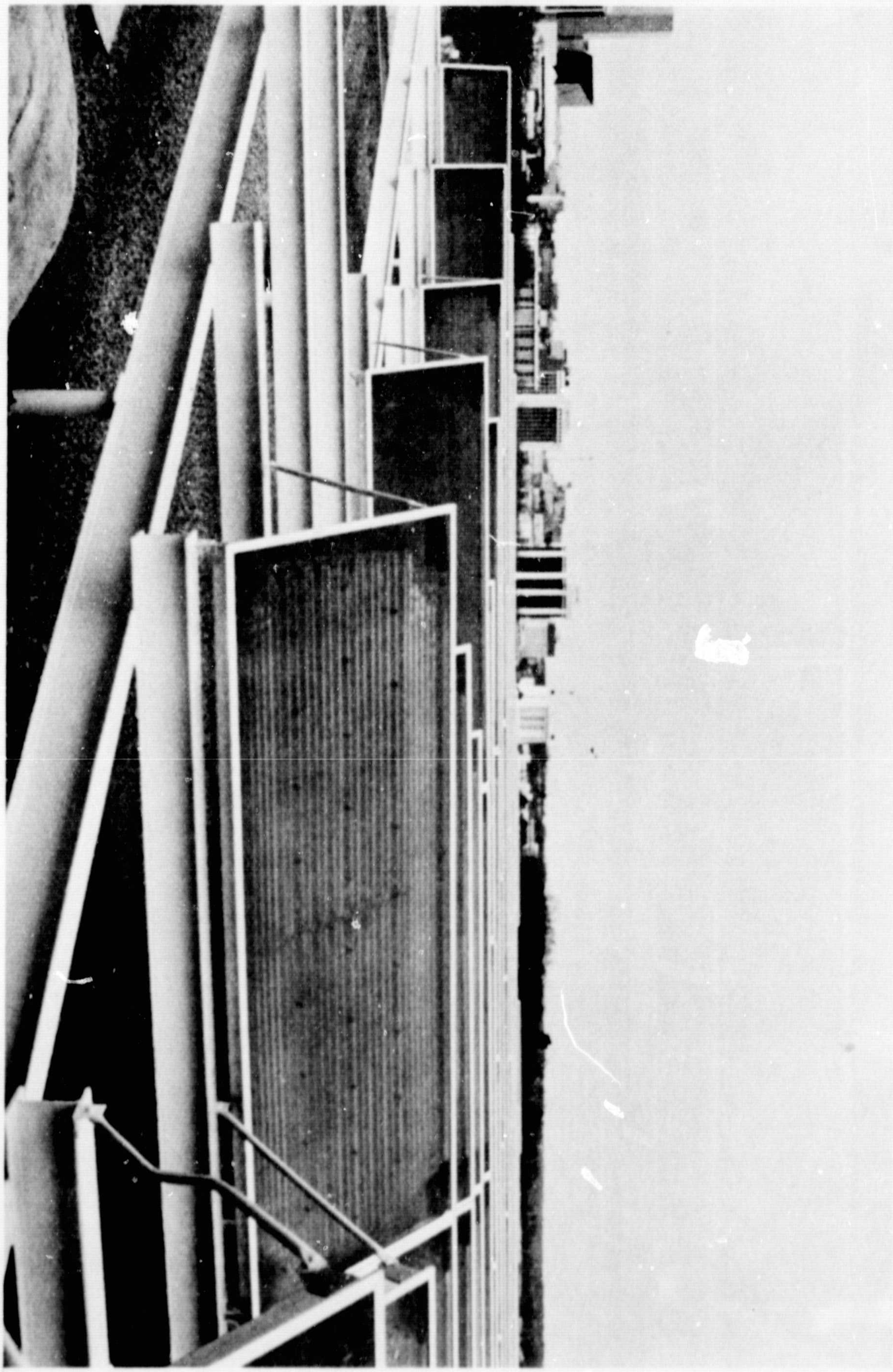
caused restricted areas in the flow path and erosion at these points caused leaks.

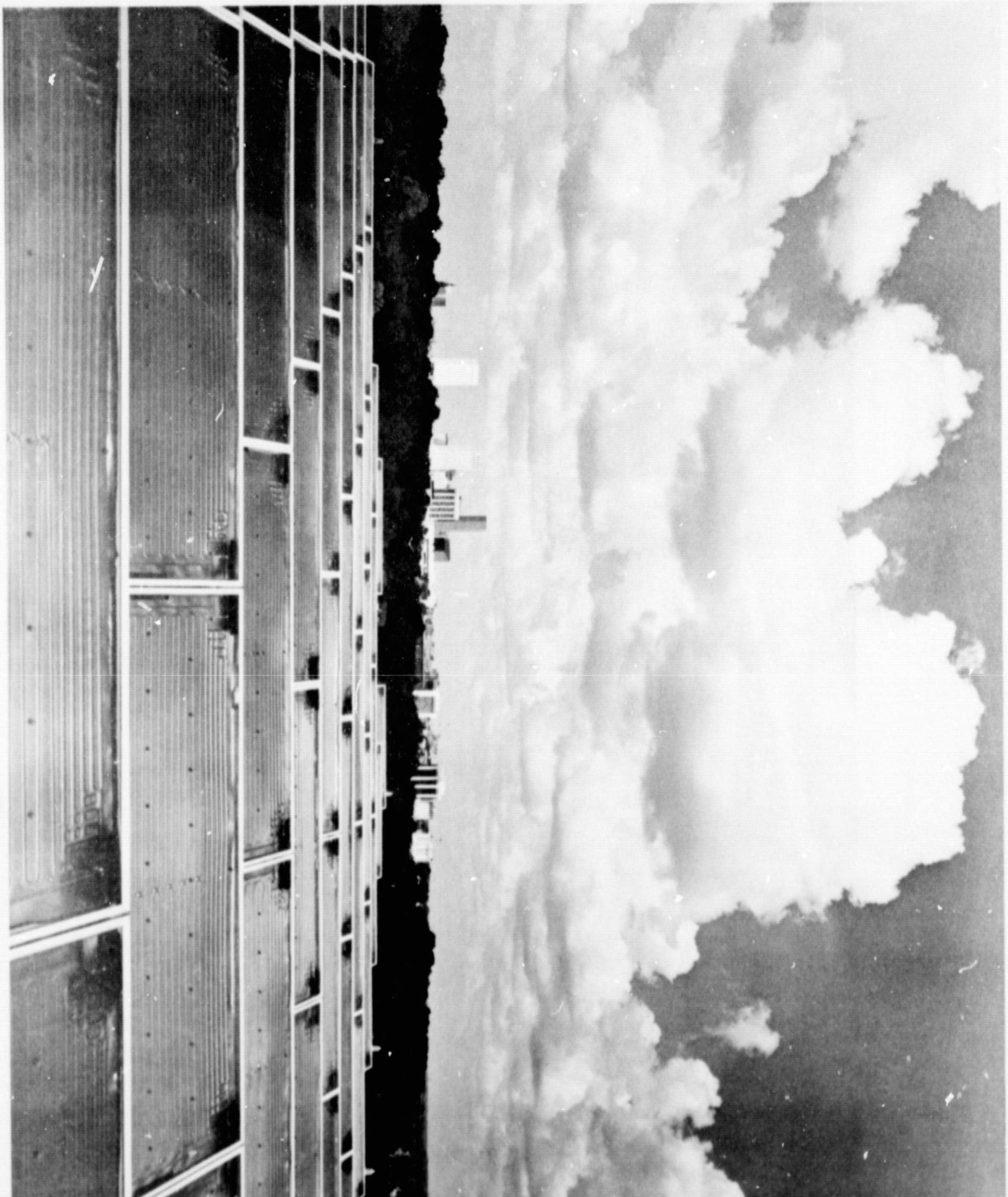
Damaged panels were replaced and seem to be working. We believe the major damage occurred during times when the panels were drained and stagnation temperature in excess of 300 degrees occurred.

APPENDIX A

PHOTOGRAPHS OF INSTALLATION

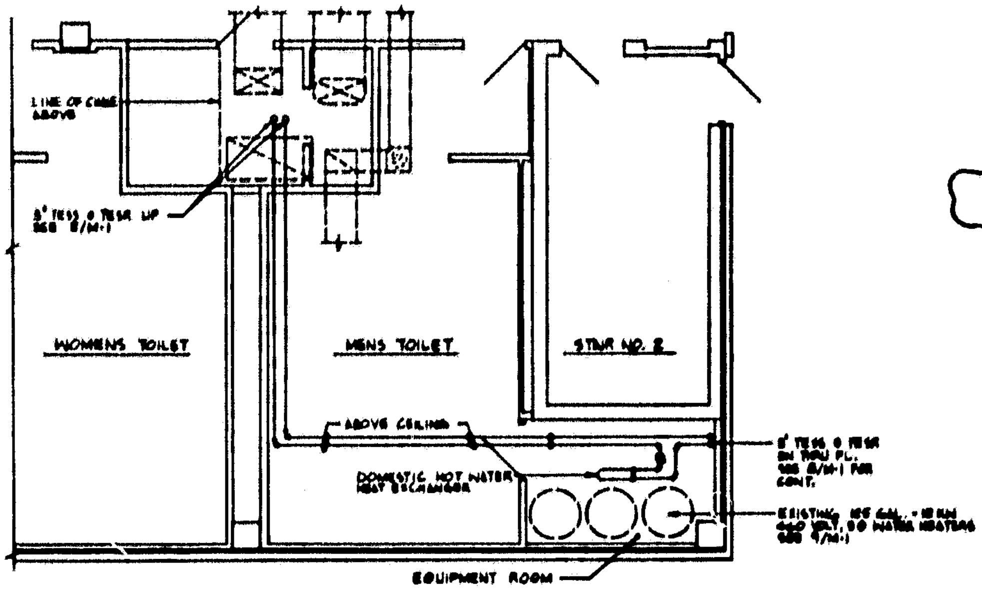




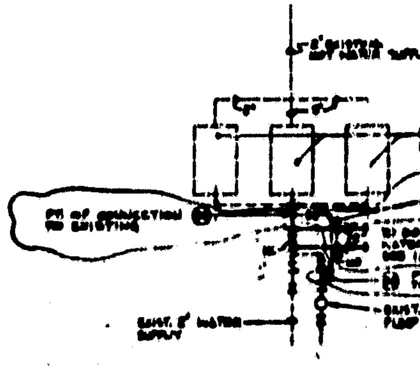


APPENDIX B

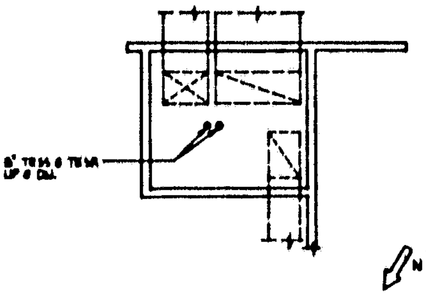
AS BUILT DRAWINGS



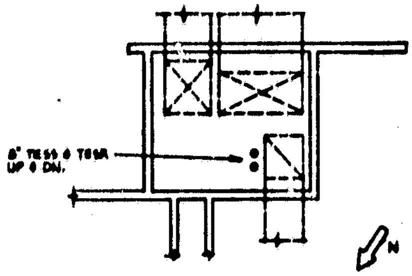
1/M-1 PARTIAL FIRST FLOOR PLAN
SCALE: 1/4" = 1'-0"



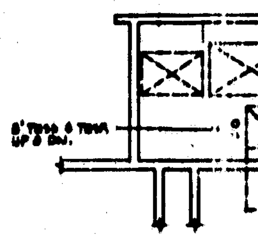
9/M-1 HOT WATER HEATER
NO SCALE



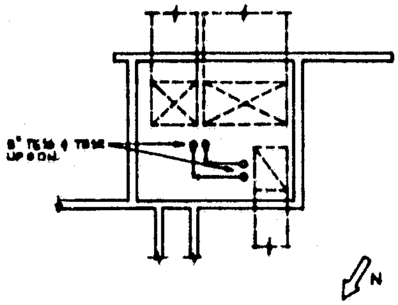
2/M-1 PLAN - CHASE SECOND FLOOR
SCALE: 1/4" = 1'-0"



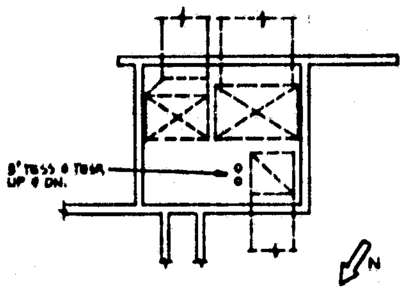
4/M-1 PLAN - CHASE FOURTH FLOOR
SCALE: 1/4" = 1'-0"



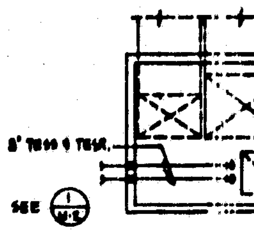
6/M-1 PLAN - CHASE SI



3/M-1 PLAN - CHASE THIRD FLOOR
SCALE: 1/4" = 1'-0"

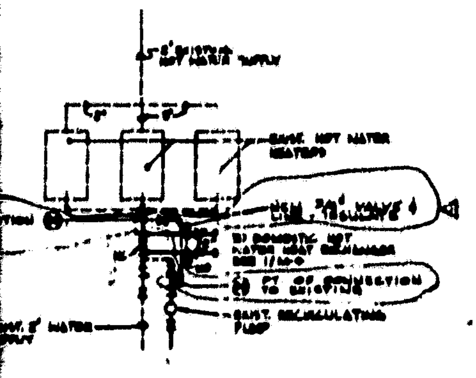


5/M-1 PLAN - CHASE FIFTH FLOOR
SCALE: 1/4" = 1'-0"



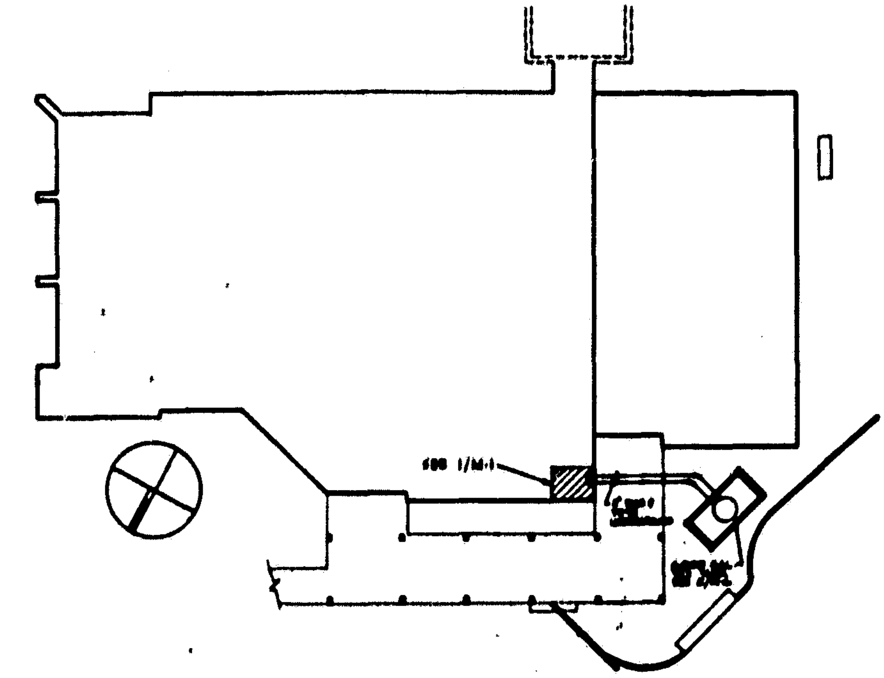
7/M-1 PLAN - CHASE
SCALE: 1/4" = 1'-0"

FOLDOUT FRAME



HOT WATER HEATER PIPING

NO SCALE

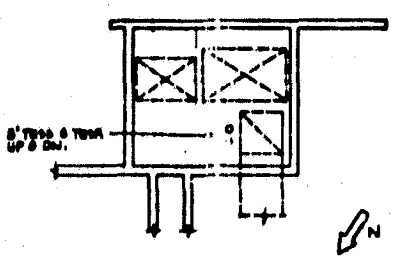


(8/M-1) SITE PLAN

SCALE: 1" = 30'-0"

LEGEND

TESS	THERMAL ENERGY STORAGE HOT WATER SUPPLY
TESR	" " " " " "
SAS	SOLAR ARRAY LOOP SUPPLY
SAR	SOLAR ARRAY LOOP RETURN
VB	VACUUM BREAKER

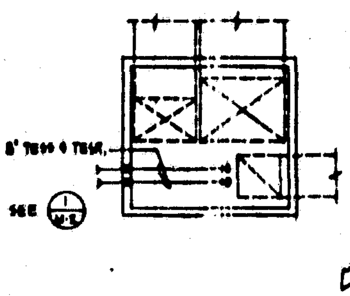


(6/M-1) PLAN - CHASE SIXTH FLOOR

SCALE: 1/4" = 1'-0"

PIPING SYMBOLS

⊗	CONNECTION OF NEW PIPING TO EXISTING PIPING
	SLOPE OF PIPING
----	EXISTING PIPING
	THERMAL ENERGY STORAGE LOOP PIPING
	DOMESTIC WATER (NEW)
	B&G CIRCUIT SETTER
	GATE VALVE
	CHECK VALVE
	3 WAY CONTROL VALVE
	GLOBE VALVE
	AIR VENT



(7/M-1) PLAN - CHASE PENTHOUSE

SCALE: 1/4" = 1'-0"

FOLDOUT FRAME 2

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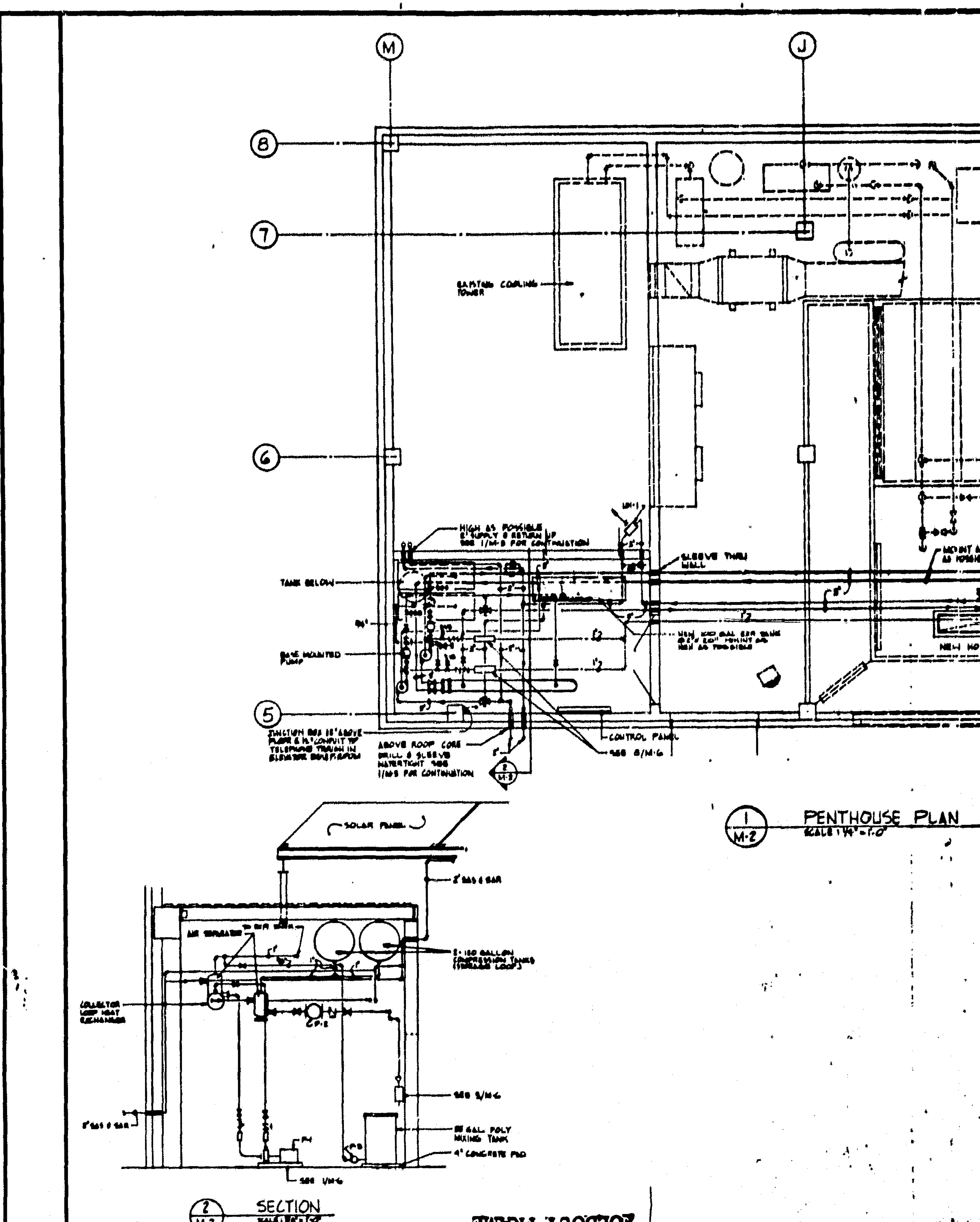
SOLAR HEATING
THE AREA HEALTH EDUCATION CENTER
CHARLOTTE, NORTH CAROLINA

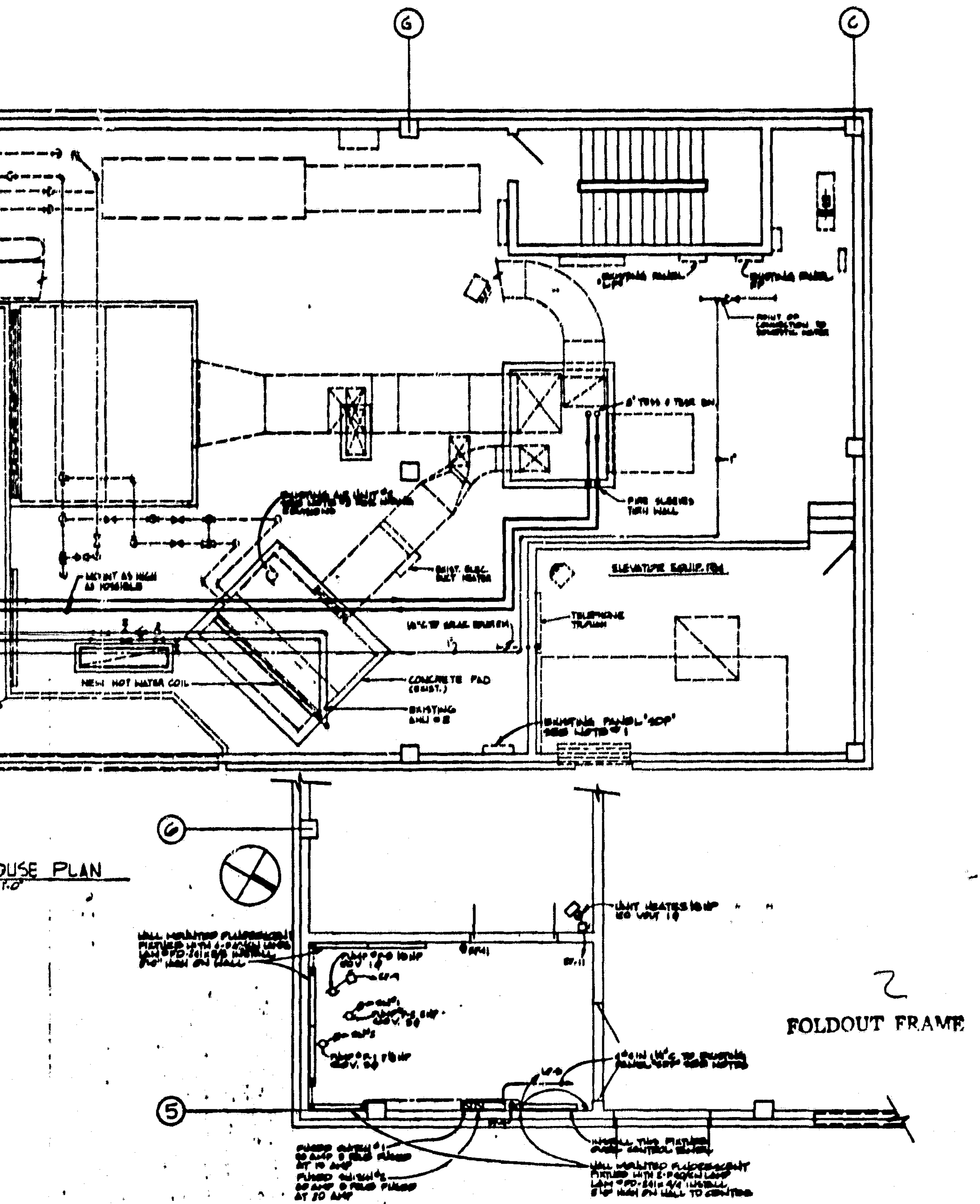
PARTIAL FIRST FLOOR PLAN, CHASE PLANS, H.W. HEATER PIPING, SITE PLAN & SYMBOLS

PROJECT NO. 23800

SHEET NO. M-1 OF 7

DATE 8-24-76


M
J
8
7
6
5
EXISTING COOLING TOWER
HIGH AS POSSIBLE 2" SUPPLY & RETURN UP SEE 1/M-3 FOR CONTINUATION
TANK BELOW
BASE MOUNTED PUMP
SLEEVE THRU WALL
JUNCTION BOX 18" ABOVE FLOOR & 1/2" CONDUIT TO TELEPHONE TROUGH IN ELEVATOR EQUIP. ROOM
ABOVE ROOF CORE DRILL & SLEEVE WATERTIGHT SEE 1/M-3 FOR CONTINUATION
CONTROL PANEL
SEE 8/M-6
NEW HO
1
M-2
PENTHOUSE PLAN
SCALE 1/4" = 1'-0"
SOLAR PANEL
2" SUPPLY & RETURN
AIR SEPARATOR
2-150 GALLON COMPRESSION TANKS (STORAGE LOOP)
COLLECTOR LOOP HEAT EXCHANGER
SEE 5/M-6
55 GAL. POLY MIXING TANK
4" CONCRETE PAD
SEE 1/M-6
2
M-2
SECTION
SCALE 1/8" = 1'-0"
FOLDOUT FRAME



NOTES:
1. PROVIDE & INSTALL A 70 AMP 3 POLE CIRCUIT BREAKER IN SPACE OF EXISTING PANEL "SDP"
2. PROVIDE & INSTALL A 40 AMP 3 POLE CIRCUIT BREAKER IN PANEL "SDP" CIRCUIT #4 IN LIEU OF 30 AMP CIRCUIT BREAKER. PROVIDE #10 IN 3/4"C TO AIR UNIT #2 IN LIEU OF #12 ORIGINALLY SPECIFIED. STARTER FOR THIS UNIT SHALL BE SIZE 2 IN LIEU OF SIZE 1
3. ELECTRICAL CONTRACTOR ADJUST LIGHT FIXTURES TO RECEIVE MAXIMUM ILLUMINATION ON FACE OF CONTROL CABINETS

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PENTHOUSE PLAN AND SECTION

SOLAR HEATING
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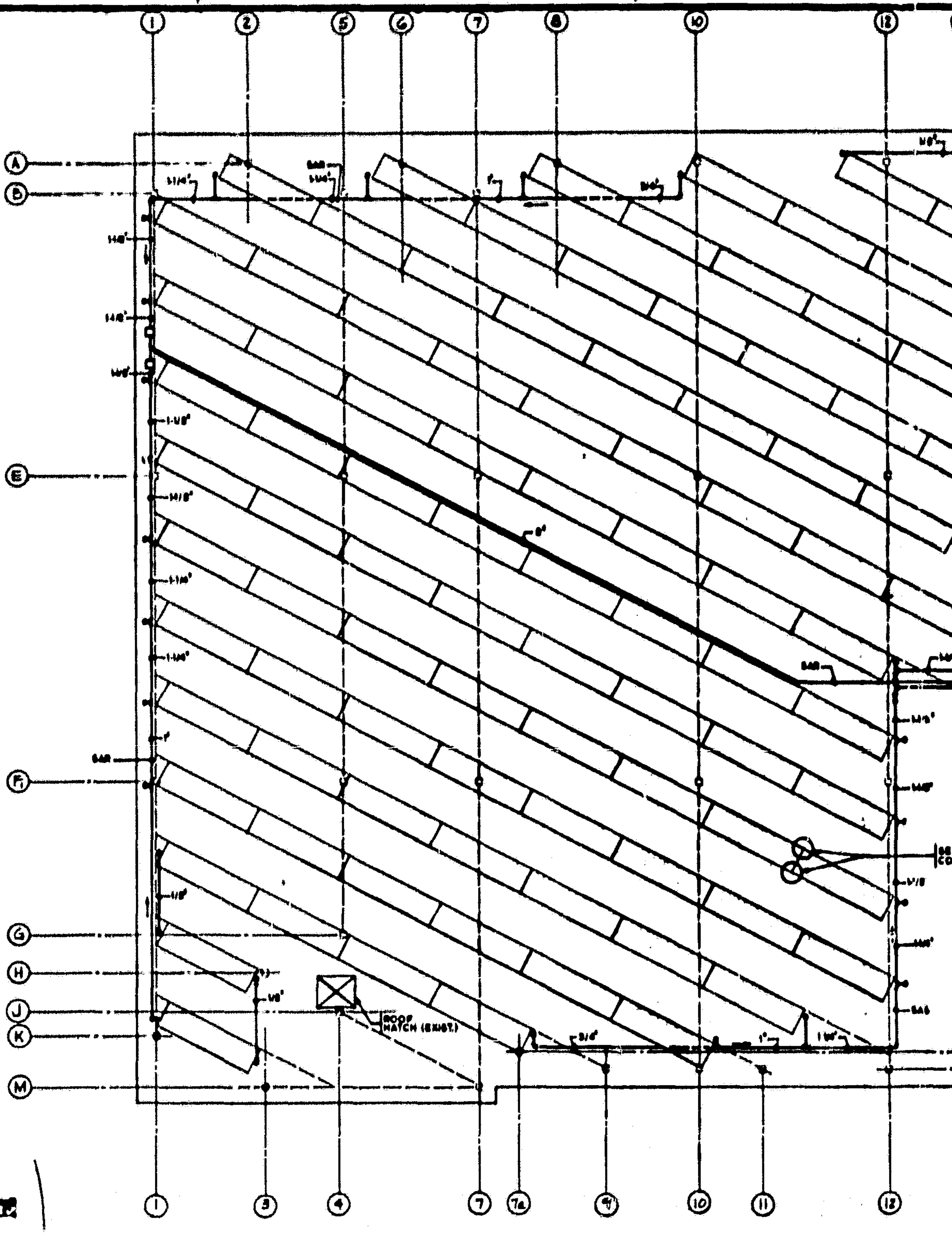
CHARLOTTE, NORTH CAROLINA

PROJECT NO. 238.00
SHEET NO. M-2
DATE 5-04-76



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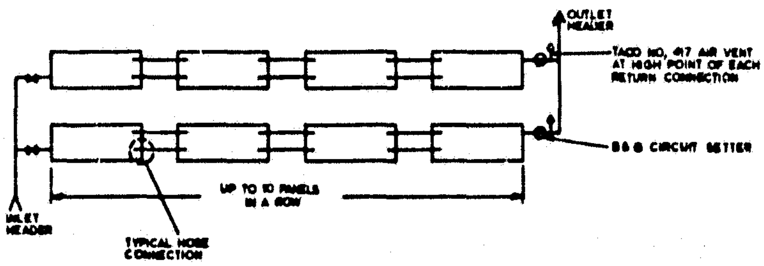
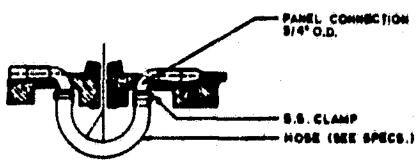
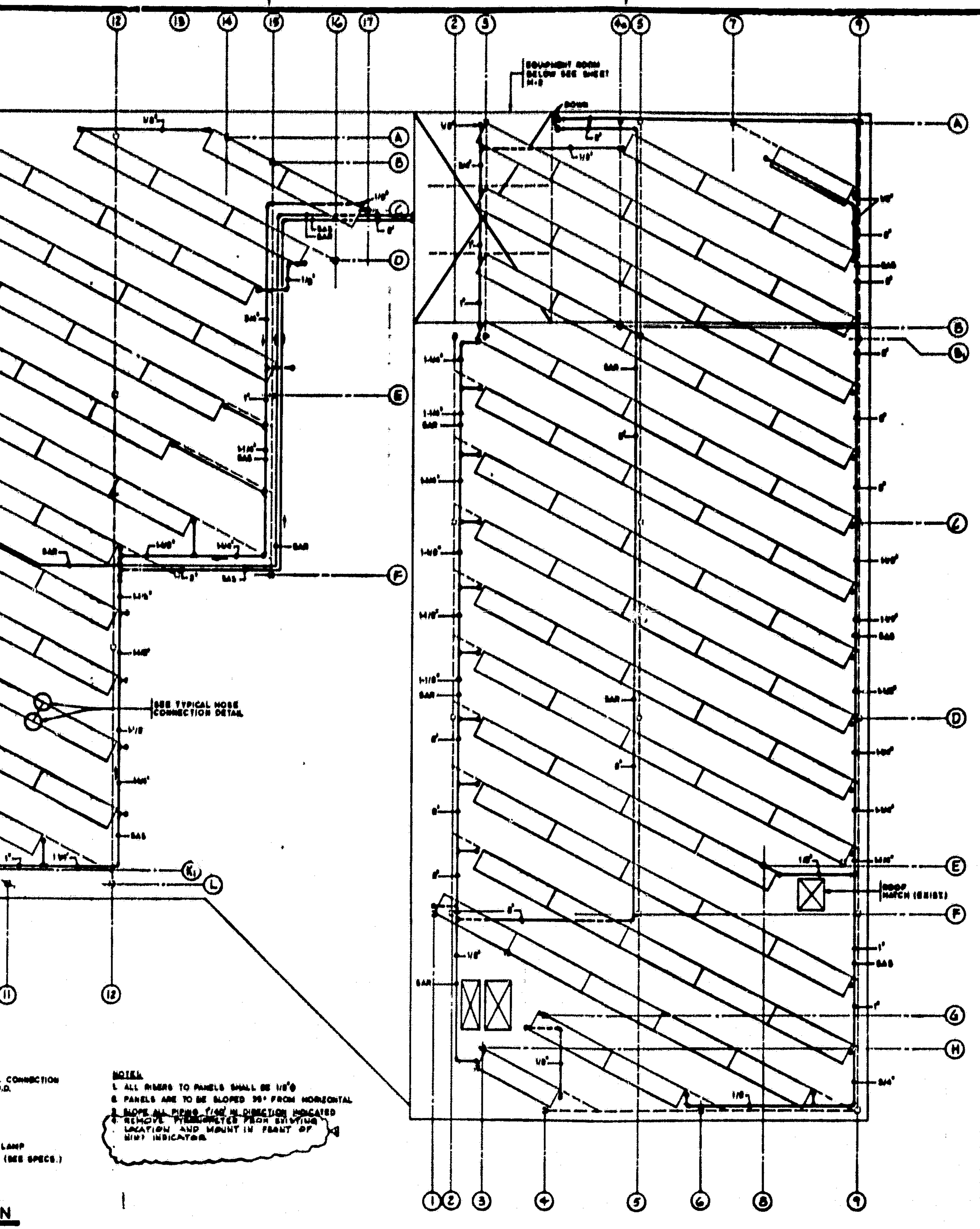


PANEL ARRAY PIPING SCHEMATIC



TYPICAL HOSE CONNECTION

NOTES:
1. ALL RISE
2. PANELS
3. SLOPE A



1
M-3
ROOF PLAN OF PANEL LAYOUT
SCALE: 3/16 = 1'-0"

FOLDOUT FRAME

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SOLAR HEATING
THE AREA HEALTH EDUCATION CENTER
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ROOF PLAN OF PANEL LAYOUT,
PIPING SCHEMATIC
& TYP. HOSE CONNECTION

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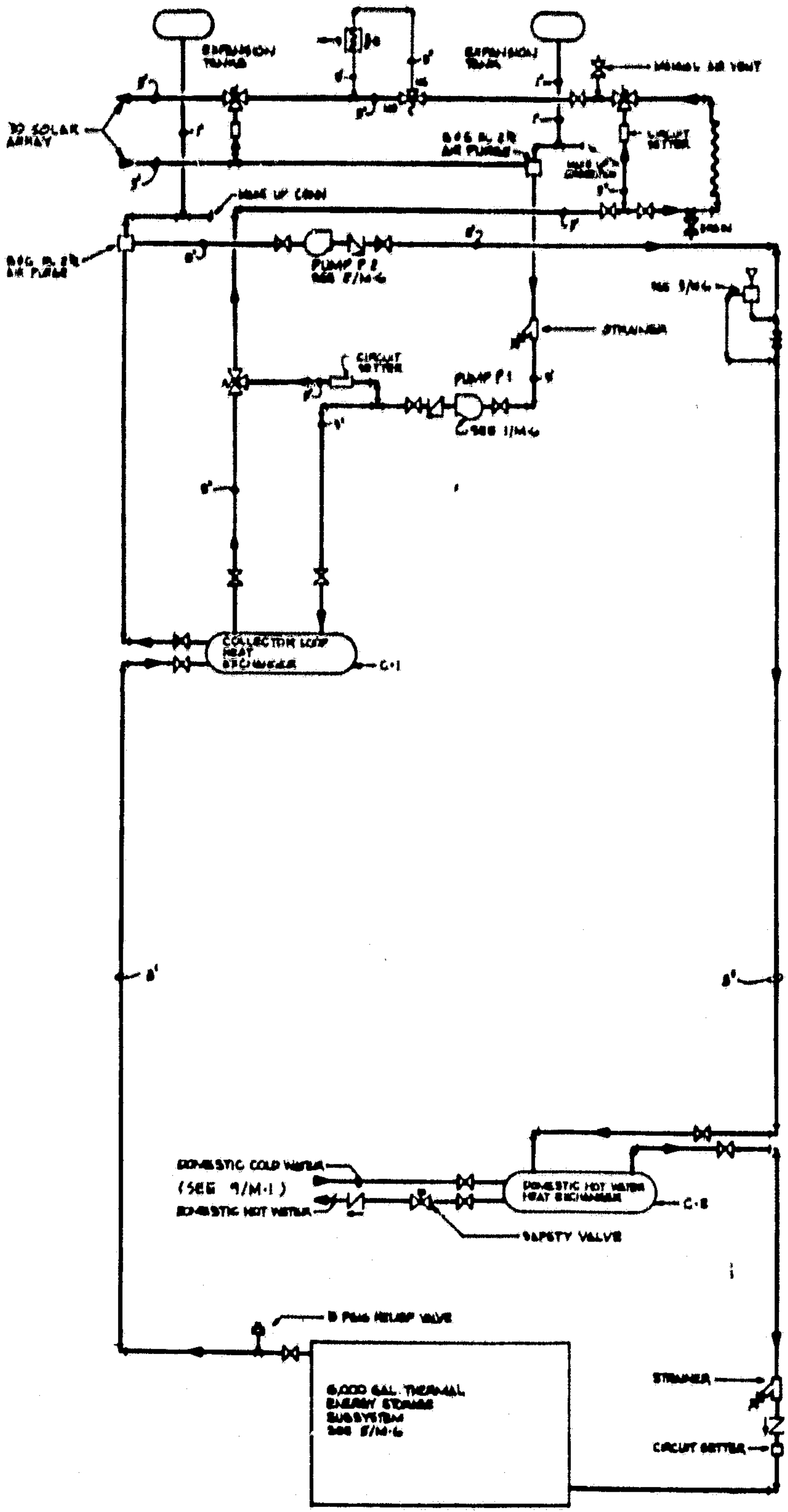
TELEPHONE 704-364-8220

REVISION	PROJECT NO.
8-16-77	238.00
	SHEET NO. M-3
DATE 8-24-76	OF 7



SYSTEM PIPING SCHEMATIC
NO SCALE

NO.	LOCATION	SERVICE
P-1	EQUIPMENT ROOM	SOLAR ARRAY
P-2	" "	STORAGE LOOP
P-3	" "	GLYCOL FILL

● ALL BRONZE

NO.	SERVICE	CAPACITY (MBH
C-1	COLLECTOR LOOP	700 MBH
C-2	DOMESTIC HOT WATER	80 MBH

● BRASS TUBE & HEAD

LOCATION	CAPACITY (MBH)
EXISTING AHU # 2	700 MBH

SYMBOL	CAPACITY (MBH)
UH-1	274 MBH

● TOTALLY ENCLOSED MOTOR

NOTES :

1. CHANGE MOTOR ON AHU # 2 FROM

FOLDOUT FRAME

PUMPS

LOCATION	SERVICE	TYPE	GPM	HEAD	RPM	HP	VOLTAGE	PHASE	STARTER	MFG. & MODEL
...PMENT ROOM	SOLAR ARRAY	BASE MTD.	85	104	1750	7 1/2	460	3Ø	MAG.	B&G SERIES 1510 1½
" "	STORAGE LOOP	INLINE	85	55	1750	2	460	3Ø	MAG.	B&G SERIES 60 2A
" "	GLYCOL FILL	INLINE	4-6	60 ft	3500	1/3	120	1Ø	——	AURORA 303

CONVERTERS

SERVICE	CAPACITY (MBH)	TUBES						SHELL						MFG. & MODEL
		FLUID	GPM	EWT	LWT	P.D.	FOULING FACTOR	FLUID	GPM	EWT	LWT	P.D.	FOULING FACTOR	
...LLECTOR LOOP	700 MBH	WATER	85.0	65°F	80°F	10.0'	0.0005	GLYCOL	85	100°F	85°F	28.0'	0.0005	TACO 80820L
...STIC HOT WATER	50 MBH	WATER	5.0	60°F	140°F	10'	0.0005	WATER	85	160°F	145°F	8.0'	0.0005	TACO B6604LN ●

● HEAD

HEATING COIL

	CAPACITY (MBH)	EWT	EAT	FLUID	GPM	P.D.	CFM (AIR)	P.D. (AIR)	FINS	ROWS	SIZE	MFG. & MODEL
...2	700 MBH	140°F	70°F	50% GYLCOL	85	6.5 FT.	15500	0.75" W.G.	10 FINS/INCH	4 ROWS	56 x 108	M'QUAY 5WS

UNIT HEATER

	CAPACITY (MBH)	EWT	EAT	FLUID	GPM	P.D.	CFM (AIR)	HP	VOLTAGE	PHASE	MFG. & MODEL
	274 MBH	200°F	90°F	60% GLY.	85	6'-0	4450	1/2	120	1Ø	AIRTHERM HR-300 ●

...ENCLOSED MOTOR

...E MOTOR ON AHU # 2 FROM 10HP TO 15 HP

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SYSTEM PIPING SCHEMATIC
AND EQUIPMENT SCHEDULES

SOLAR HEATING
THE AREA HEALTH EDUCATION CENTER
CHARLOTTE, NORTH CAROLINA

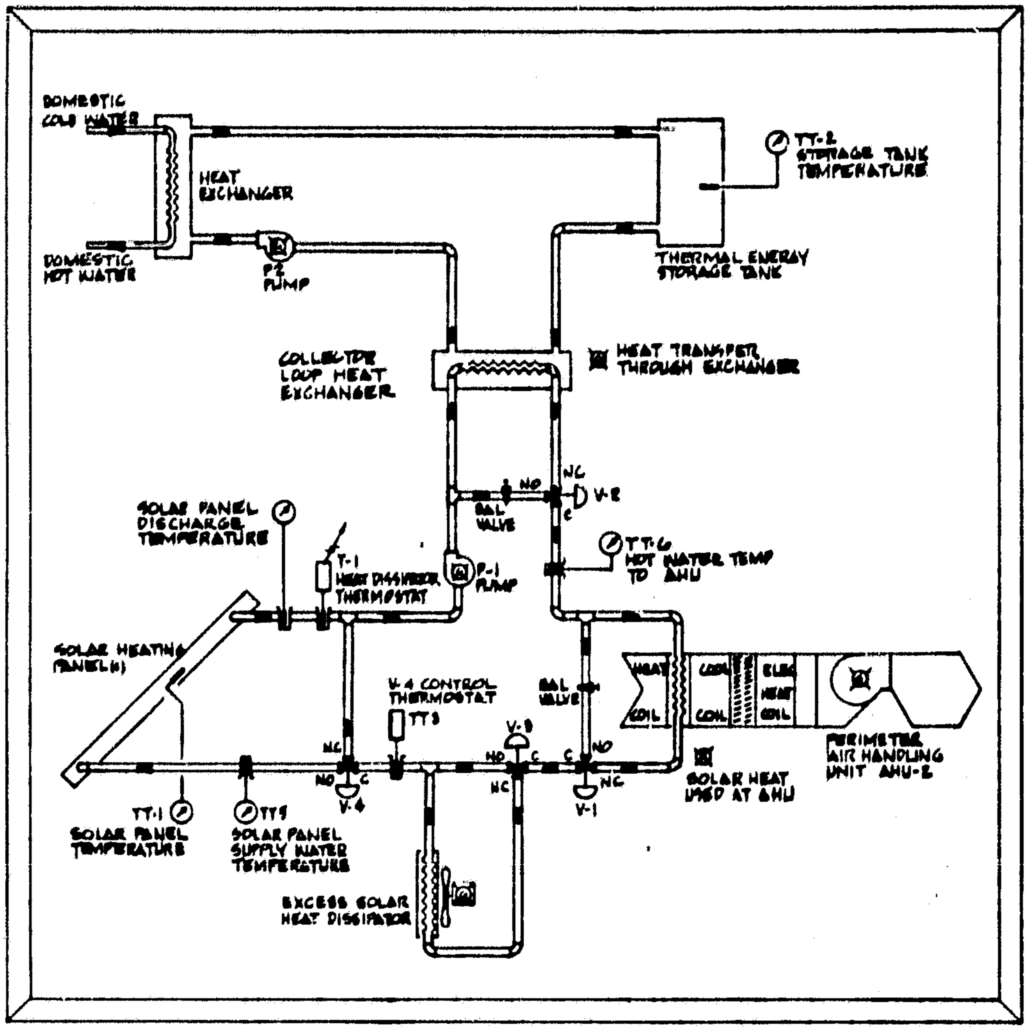
REVISION 11-28-77, 8-07-79

PROJECT NO. 23800

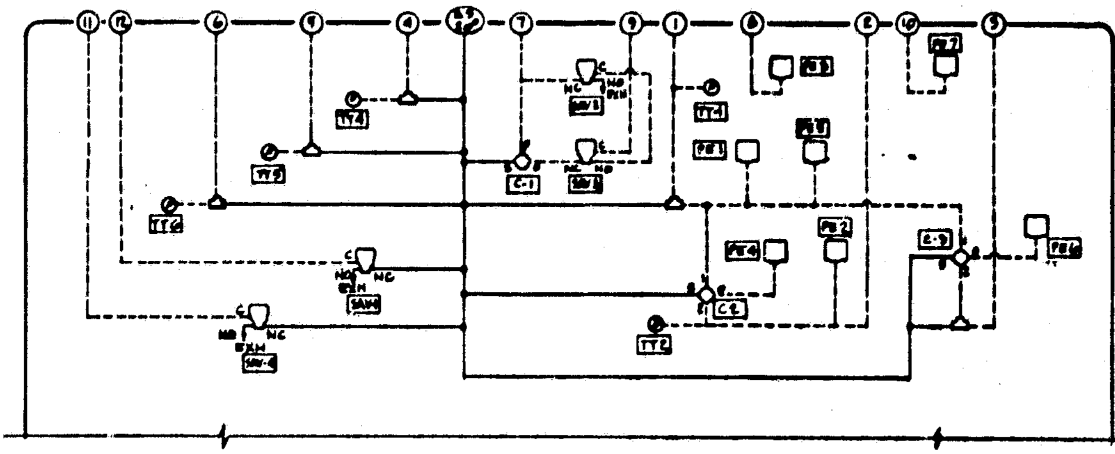
SHEET NO. M-4

DATE 5-24-76

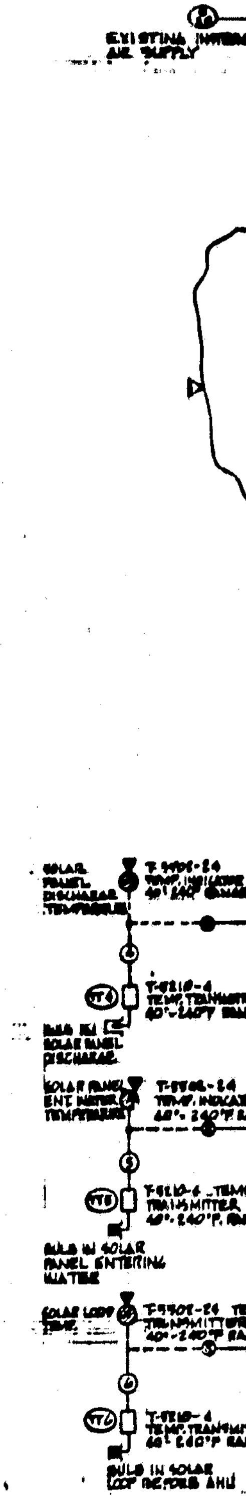
FOLDOUT FRAME 2



PANEL FACE CP-101



PNEUMATIC PIPING _ CP-101
(FOR PANEL WIRING, SEE SHEET 2)



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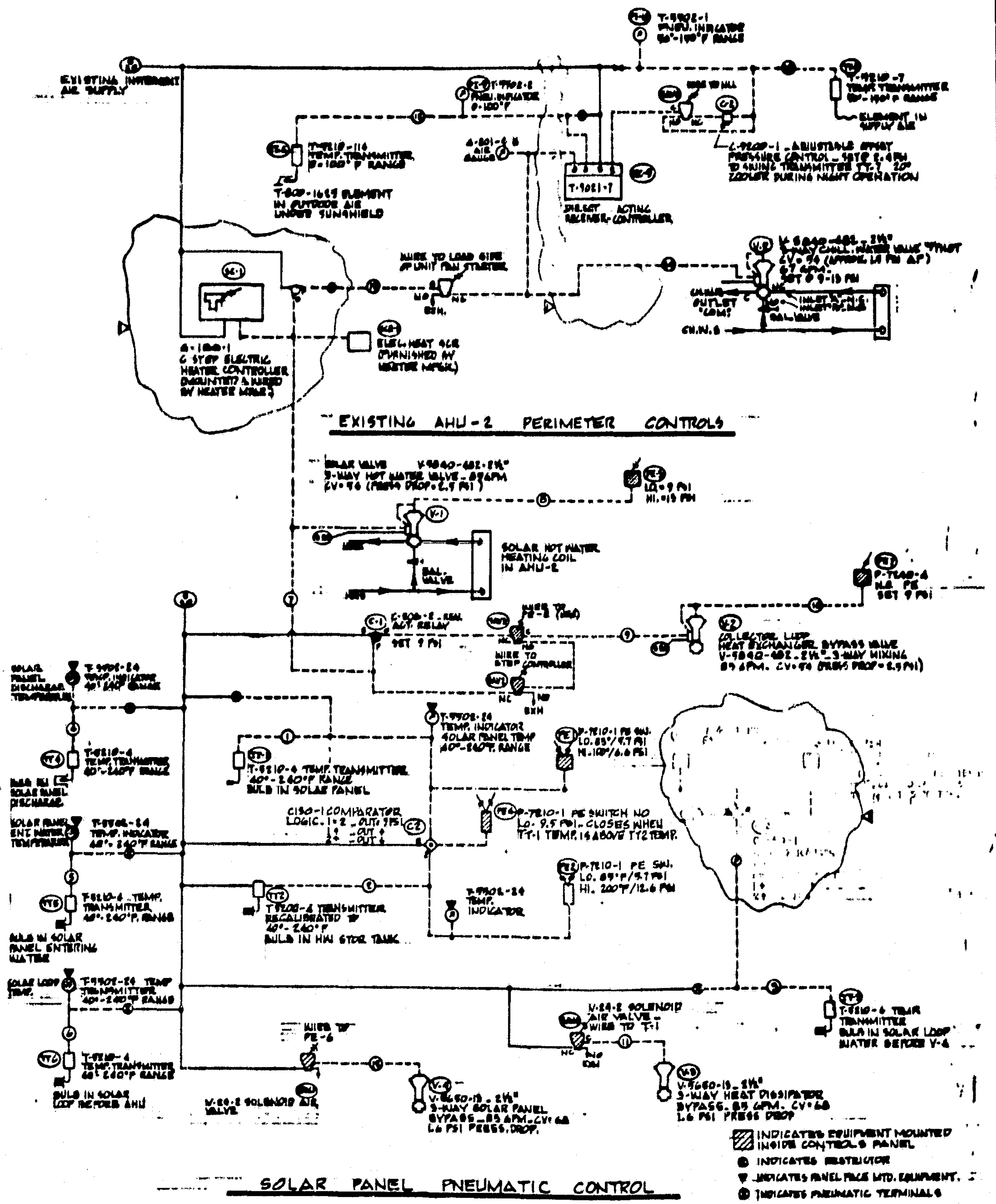

EXISTING AHU-2 PERIMETER CONTROLS

SOLAR PANEL PNEUMATIC CONTROL

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CONTROLS

SOLAR HEATING
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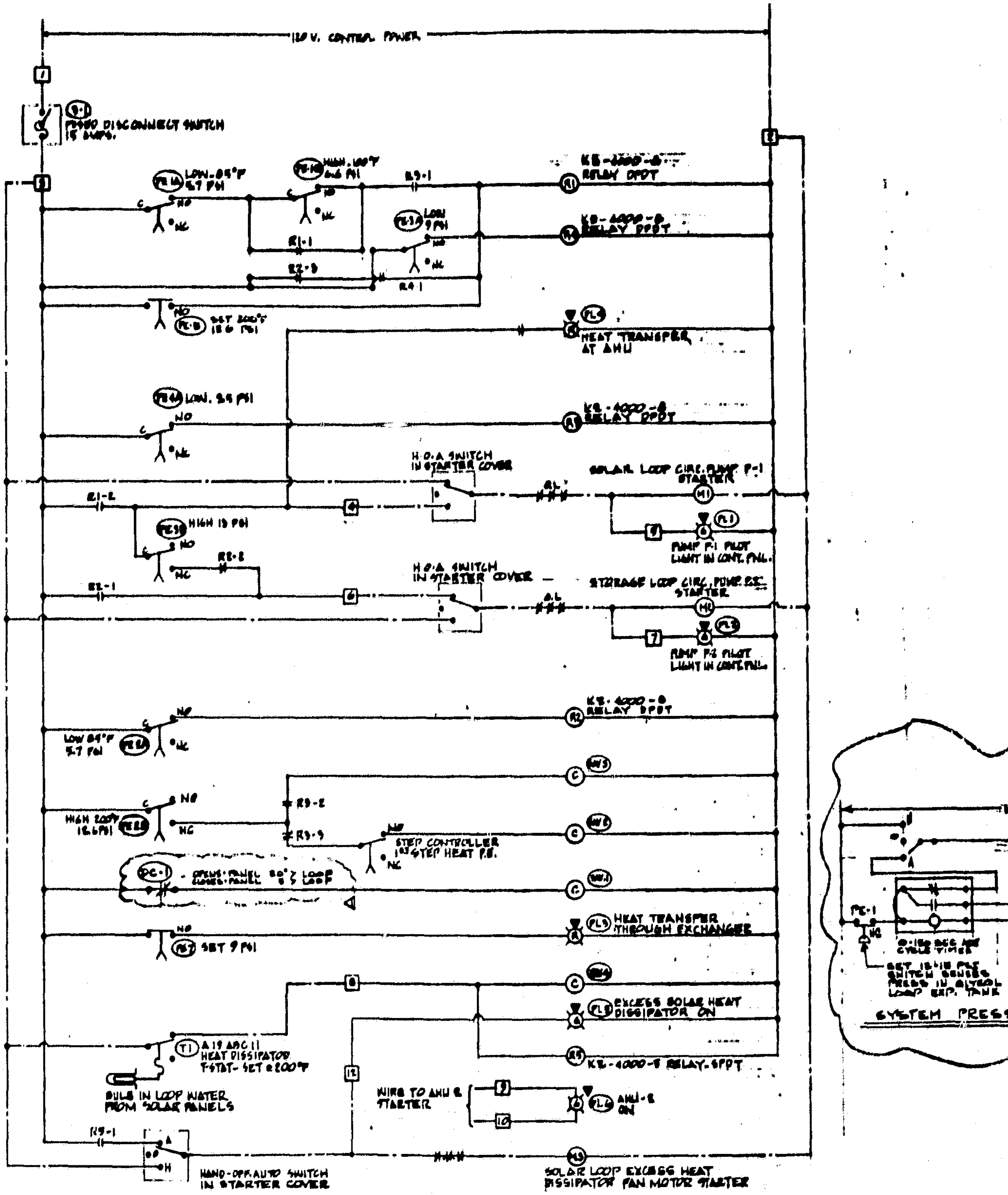
M-5

FOLDOUT FRAME 2



SOLAR PANEL ELECTRICAL CONTROL

▼ INDICATES PANEL FACE MOUNTED EQUIPMENT

☐ INDICATES ELECTRICAL TERMINALS

—·—·— INDICATES FIELD WIRING

——— INDICATES INTERNAL PANEL WIRING

FOLDOUT FRAME

AREA HEALTH EDUCATION CENTER
SEQUENCE OF OPERATION

PUMP P-1 IS STARTED WHEN:

(1) SOLAR PANEL TEMPERATURE RISES ABOVE 100°F.
(2) THE STORAGE TANK TEMPERATURE IS ABOVE 80°F AND THE AIR HANDLING UNIT IS CALLING FOR HEAT.

PUMP P-1 IS STOPPED WHEN:

(1) SOLAR TEMPERATURE DROPS BELOW 80°F.
(2) THE STORAGE TANK TEMPERATURE IS BELOW 80°F AND/OR THE AIR HANDLING UNIT IS NOT CALLING FOR HEAT.

VALVE V-1:

(1) MODULATES ON A CALL FOR HEAT FROM THE AIR HANDLING UNIT CONTROLS.

VALVE V-2:

(1) BYPASSES THE HEAT EXCHANGER WHEN SOLAR PANEL WATER TEMPERATURE IS BELOW STORAGE TANK TEMPERATURE AND VALVE V-4 IS OPEN TO THE SOLAR PANEL.
(2) IS OPEN TO THE HEAT EXCHANGER WHEN THE SOLAR PANEL TEMPERATURE IS ABOVE THE STORAGE TANK TEMPERATURE AND THE AHU IS NOT CALLING FOR HEAT.
(3) IS OPEN TO THE HEAT EXCHANGER WHEN VALVE V-4 IS BYPASSING THE SOLAR PANEL AND THE AHU IS CALLING FOR HEAT.
(4) MODULATES WHEN SOLAR PANEL TEMPERATURE IS ABOVE THE STORAGE TANK TEMPERATURE AND THE AHU CONTROLS ARE MODULATING VALVE V-1.

VALVE V-3:

(1) BYPASSES THE UNIT HEATER WHEN THE COLLECTOR LOOP TEMPERATURE IS BELOW 200°F.
(2) IS OPEN TO THE UNIT HEATER WHEN LOOP TEMPERATURE EXCEEDS 200°F TO DISSIPATE EXCESS HEAT.

VALVE V-4: IS OPEN TO PANEL ANYTIME PANEL TEMP IS 10° > THAN SOLAR LOOP; CLOSED WHEN PANEL TEMP IS 5° > THAN LOOP.

~~(1) BYPASSES THE SOLAR PANEL WHEN PANEL TEMPERATURE IS BELOW 80°F AND STORAGE TANK TEMPERATURE IS ABOVE 80°F AND THE AHU IS CALLING FOR HEAT.~~
~~(2) IS OPEN TO THE SOLAR PANEL ANYTIME THE ABOVE CONDITION DOES NOT EXIST.~~

PUMP P-2 RUNS:

(1) WHEN STORAGE TANK TEMPERATURE IS ABOVE 80°F.
(2) WHEN STORAGE TANK TEMPERATURE IS BELOW 80°F AND SOLAR HEAT IS AVAILABLE FOR STORAGE.

INTERLOCK WIRING OPERATION:

GENERAL CONDITIONS: STORAGE TANK TEMPERATURE BELOW 80°F, SOLAR PANEL TEMPERATURE BELOW 80°F.

AS SOLAR ENERGY HEATS THE SOLAR PANEL ABOVE 80°F, PRESSURE SWITCH PE-1 LOW SIDE CONTACT (N.O.) MAKES. AS PANEL TEMPERATURE INCREASES ABOVE 100°F, RELAY R-1 IS ENERGIZED THROUGH PE-1 HIGH SIDE CONTACT (N.O.) RELAY R1-2 CONTACT STARTS PUMP P-1. RELAY R-1 CONTACT PREVENTS PUMP P-1 FROM DE-ENERGIZING UNTIL PANEL TEMPERATURE DROPS BELOW 80°F.

WITH STORAGE TANK TEMPERATURE BELOW 80°F AND THE AHU CALLING FOR MAXIMUM HEAT, PRESSURE SWITCH PE-4 CONTACT IS MADE ENERGIZING SOLENOID AIR VALVE SAV-3. AHU HEATING VALVE V-1 CONTROL AIR IS SUPPLIED THROUGH C-1 TO SAV-3. C-1 IS A REVERSE ACTING COMPARATOR SO THAT WHEN V-1 IS FULL OPEN TO THE AHU HEATING COIL, VALVE V-2 IS IN THE FULL BYPASS POSITION TO THE HEAT EXCHANGER. AS THE AHU CONTROLS BECOME SATISFIED, VALVE V-1 IS MODULATED TOWARD THE BY-PASS POSITION ON THE AHU HEATING COIL WHILE VALVE V-2 IS MODULATED OPEN TO THE HEAT EXCHANGER. WHEN VALVE V-2 BEGINS TO OPEN TO THE HEAT EXCHANGER, PRESSURE SWITCH PE-5 IS OPERATED TO START PUMP P-2. AS STORAGE TANK TEMPERATURE INCREASES ABOVE 80°F, PE-2 LOW SIDE CONTACTS TRANSFER TO KEEP P-2 RUNNING CONTINUOUSLY.

WHEN STORAGE TANK TEMPERATURE IS BELOW 80°F, VALVES V-1 AND V-2 MODULATE ACCORDING TO AHU CONTROL SIGNALS AND PUMP P-2 IS CYCLED BY PE-5 WHENEVER ANY EXCESS HEAT IS AVAILABLE FOR STORAGE.

WHEN STORAGE TANK TEMPERATURE IS ABOVE THE SOLAR PANEL TEMPERATURE, PE-4 CONTACTS TRANSFER AND VALVE V-2 GOES TO FULL BYPASS POSITION TO THE HEAT EXCHANGER THROUGH THE DE-ENERGIZATION OF SOLENOID AIR VALVE SAV-3.

GENERAL CONDITIONS: STORAGE TANK TEMPERATURE ABOVE 80°F, SOLAR PANEL TEMPERATURE BELOW 80°F.

WITH STORAGE TANK TEMPERATURE ABOVE 80°F, PRESSURE SWITCH PE-2 LOW SIDE CONTACTS (N.O.) ARE CLOSED AND PUMP P-2 IS OPERATING. WHEN AHU CONTROLS CALL FOR HEATING, PRESSURE SWITCH PE-3 CONTACTS MAKE, ENERGIZING RELAY R-2 TO START PUMP P-1. SINCE SOLAR PANEL TEMPERATURE IS BELOW 80°F, PE-1 LOW SIDE CONTACTS (N.O.) ARE CLOSED AND SOLENOID AIR VALVE SAV-2 IS ENERGIZED. VALVE V-2 IS POSITIONED FULL OPEN TO THE HEAT EXCHANGER. SINCE RELAY R-1 IS NOT ENERGIZED, SOLENOID AIR VALVE SAV-1 IS ALSO ENERGIZED THROUGH CONTACTS R1-3. SAV-1 OPERATES VALVE V-4 TO COMPLETELY BY-PASS THE SOLAR PANEL. HEAT STORED IN THE STORAGE TANK IS NOW PUMPED THROUGH THE HEAT EXCHANGER. PUMP P-1 PICKS UP THIS STORED HEAT AND PUMPS IT THROUGH THE AHU COIL AS DETERMINED BY THE MODULATING OF VALVE V-1.

GENERAL CONDITIONS: STORAGE TANK TEMPERATURE ABOVE 200°F, SOLAR PANEL TEMPERATURE ABOVE 200°F.

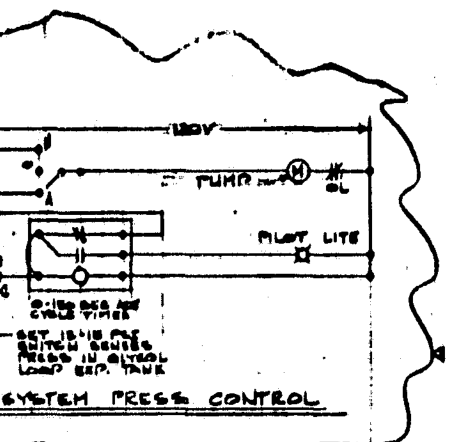
AS SOLAR LOOP TEMPERATURE INCREASES ABOVE 200°F, PRESSURE SWITCH PE-2 HIGH SIDE CONTACTS (N.O.) TRANSFER TO DE-ENERGIZE SOLENOID AIR VALVE SAV-3 AND PLACE THE HEAT EXCHANGER BYPASS VALVE TO THE FULL BYPASS POSITION. PUMP P-2 CONTINUES TO OPERATE TO PRE-HEAT DOMESTIC HOT WATER. PE-2 HIGH SIDE CONTACTS CYCLE SOLENOID AIR VALVE SAV-2 TO MAINTAIN A MAXIMUM TEMPERATURE OF 200°F IN THE STORAGE TANK.

DOMESTIC HOT WATER ALARM
SEQUENCE OF OPERATION

PRESSURE TRANSMITTERS PT-1 AND PT-2 SENSE DOMESTIC HOT WATER PRESSURE AND SOLAR HEAT STORAGE LOOP WATER PRESSURE RESPECTIVELY. IF DOMESTIC HOT WATER PRESSURE AND STORAGE LOOP PRESSURE BECOME EQUAL OR LOOP PRESSURE EXCEEDS DOMESTIC HOT WATER PRESSURE, THE SIGNAL COMPARATOR WILL POSITION PRESSURE SWITCH PE-6 TO DE-ENERGIZE RELAY R-1. WHEN RELAY R-1 DE-ENERGIZES, SOLENOID AIR VALVE SAV-6 IS DE-ENERGIZED WHICH CLOSES THE DOMESTIC HOT WATER SUPPLY VALVE.

THE DOMESTIC HOT WATER SUPPLY VALVE PREVENTS ANY POSSIBLE CONTAMINATION FROM ENTERING THE DOMESTIC HOT WATER SYSTEM IN CASE THERE HAS BEEN ANY LEAKAGE FROM THE SOLAR STORAGE LOOP INTO THE DOMESTIC HOT WATER SUPPLY.

A SILENCE SWITCH LOCATED ON THE MONITOR PANEL WILL SILENCE THE DOMESTIC HOT WATER CONTAMINATION ALARM BELL. WHEN PROPER SYSTEM PRESSURES HAVE BEEN RE-ESTABLISHED, I.E. DOMESTIC HOT WATER PRESSURE GREATER THAN SOLAR LOOP STORAGE PRESSURE AND DOMESTIC HOT WATER HAS BEEN TESTED FOR POSSIBLE CONTAMINATION, THEN THE PANEL RESET BUTTON MAY BE DEPRESSED TO RETURN THE PANEL TO ITS ORIGINAL STANDBY POSITION. LOSS OF CONTROL AIR PRESSURE OR A LOSS OF CONTROL POWER TO THE MONITOR PANEL WILL CAUSE THE PANEL TO FAIL SAFE TO THE ALARM POSITION. CORRECTING THE PROBLEM AND RESETTING THE PANEL WILL RESTORE NORMAL OPERATION.



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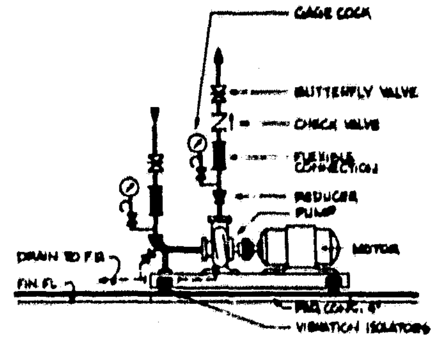
CONTROLS WIRING AND DESCRIPTION

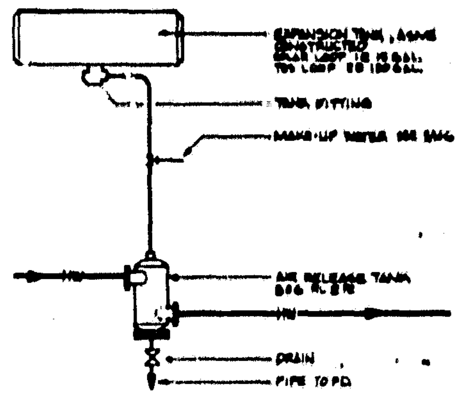
SOLAR HEATING
THE AREA HEALTH EDUCATION CENTER
CHARLOTTE, NORTH CAROLINA

REVISION	PROJECT NO
8-17-79	23800
DATE	SHEET NO
5-24-76	M5A OF 7

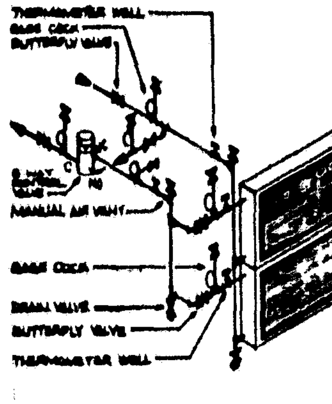
FOLDOUT FRAME



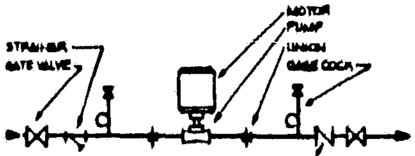
1/M-6 WATER PUMP-END SUCTION



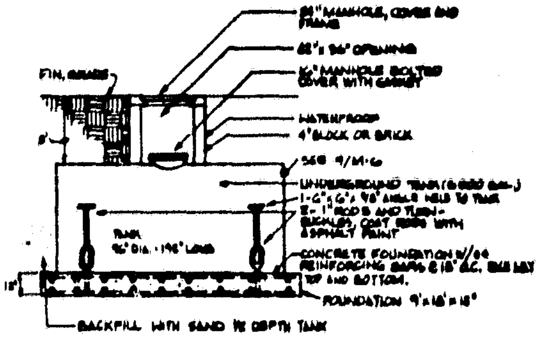
4/M-6 AIR RELEASE TANK DETAIL



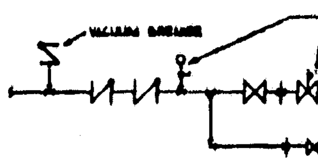
7/M-6 WATER COIL PIPING INST



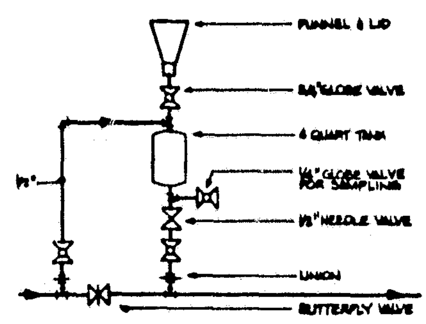
2/M-6 INLINE PUMP INSTALLATION



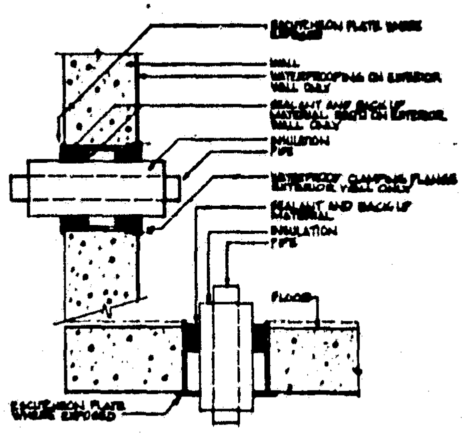
5/M-6 UNDERGROUND TANK DETAIL



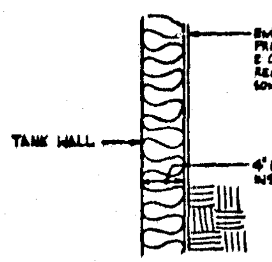
8/M-6 MAKE-UP WATER CO



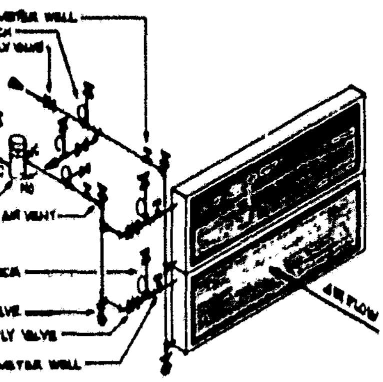
3/M-6 BYPASS CHEMICAL FEEDER



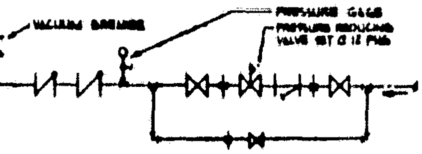
6/M-6 PIPE SLEEVE DETAIL



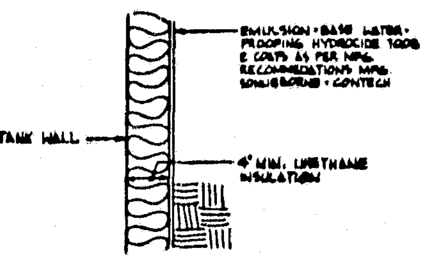
9/M-6 TANK INSULATION



ER COIL PIPING INSTALLATION



KE-UP WATER CONNECTION



TANK INSULATION

FOLDOUT FRAME 2

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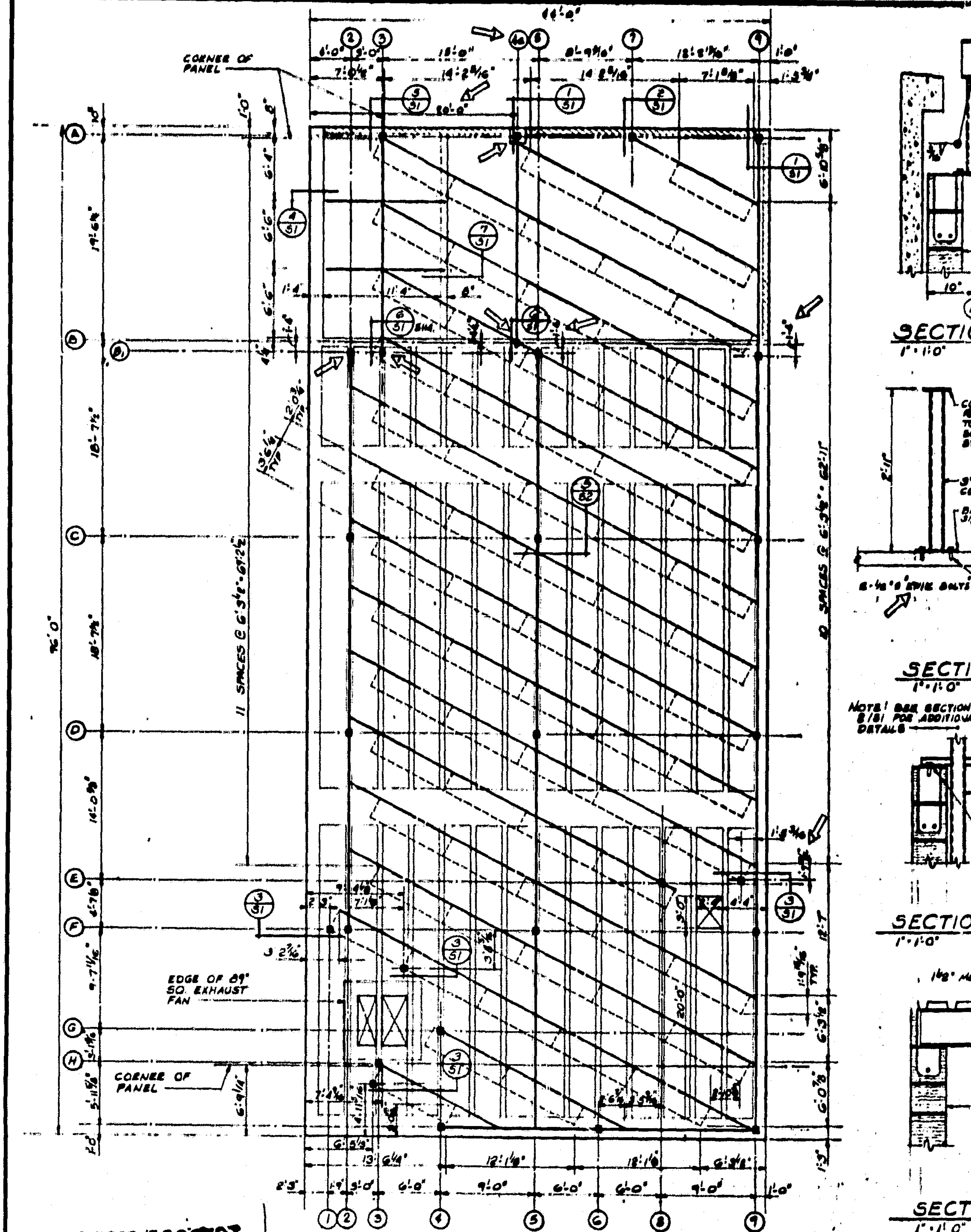
ENGINEERS, INCORPORATED

DETAILS

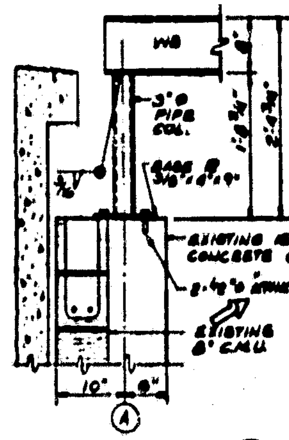
SOLAR HEATING
THE AREA HEALTH EDUCATION CENTER
CHARLOTTE, NORTH CAROLINA

REVISION

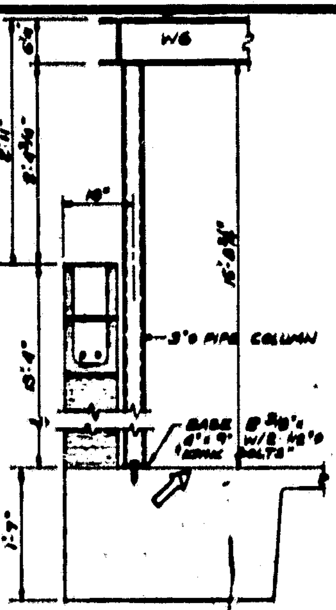
M-6



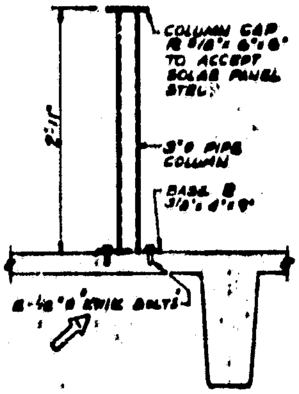
PENTHOUSE ROOF PLAN (71 PANELS)
3/16" = 1' 0"



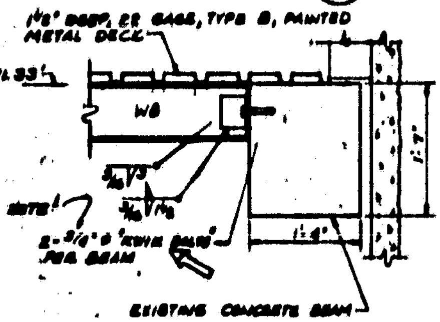
SECTION 1/S1
1" = 1'-0"



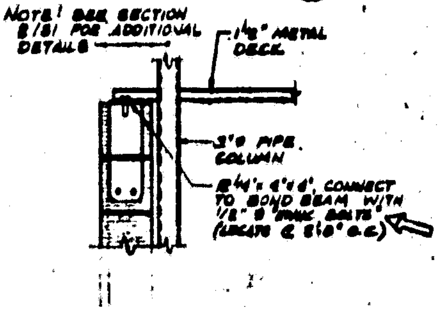
SECTION 2/S1
1" = 1'-0"



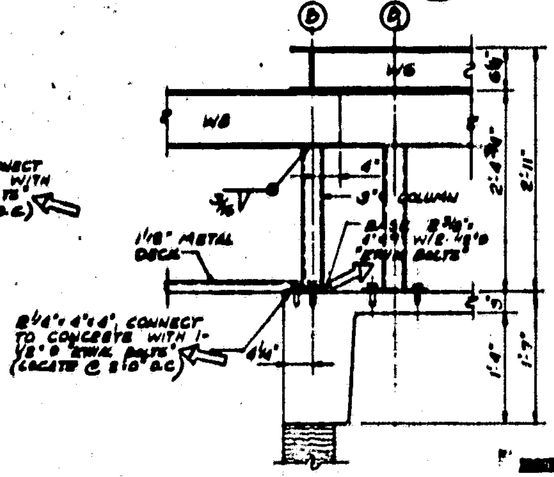
SECTION 3/S1
1" = 1'-0"



SECTION 4/S1
1" = 1'-0"

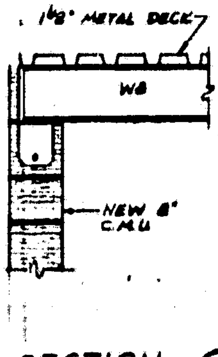


SECTION 5/S1
1" = 1'-0"



SECTION 6/S1
1" = 1'-0"

DETAILS AT COLS. B&6 & 2,5 SHOWN. COL. 8,2 SIM. TO 8,5



SECTION 7/S1
1" = 1'-0"

GENERAL NOTES

1. DESIGN LIVE LOADS: [illegible] PSF HORIZONTAL PROJECTION
   [illegible] PSF DOWNWARD NORMAL TO SLOPED SURFACE
   [illegible] PSF PROJECTED UPWARD NORMAL TO SLOPED SURFACE
2. METHODS OF CONSTRUCTION AND ERECTION OF MATERIAL IS THE CONTRACTOR'S RESPONSIBILITY.
3. STRUCTURAL DRAWINGS SHALL BE USED IN CONJUNCTION WITH DRAWINGS OF [illegible] AND OTHER CONTRACT DRAWINGS.
4. SUBMIT ONE SEPIA AND ONE SET OF PRINTS OF SHOP DRAWINGS OF ALL STRUCTURAL MATERIALS FOR APPROVAL BEFORE FABRICATION.
5. NO FIELD CUTTING OF STRUCTURAL MEMBERS BY ANY TRADE WILL BE ALLOWED WITHOUT PRIOR APPROVAL OF THE STRUCTURAL ENGINEER.

STRUCTURAL STEEL

6. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM A36.
7. DESIGN, DETAILING, FABRICATION AND ERECTION OF STRUCTURAL STEEL SHALL BE IN ACCORDANCE WITH THE AMERICAN INSTITUTE OF STEEL CONSTRUCTION CODE AND DETAILING MANUAL (SEE LATEST EDITION)
8. ALL CONNECTIONS BETWEEN STRUCTURAL STEEL MEMBERS SHALL BE WELDED USING E70XX ELECTRODES IN ACCORDANCE WITH AWS STANDARDS AND AS SHOWN ON STRUCTURAL DRAWINGS.
9. ALL SHOP AND FIELD WELDING SHALL BE BY CERTIFIED WELDERS AND SHALL CONFORM TO AWS STANDARDS.

MATERIAL TAKEOFF

W6 x 20	SHEET	S1	-	6.233	TONS
	"	S2	-	8.762	"
W8 x 17	"	S1	-	2.717	"
	"	S2	-	3.400	"
3"⌀ TUBE	"	S1	-	.318	"
	"	S2	-	.260	"
		TOTAL	-	21.69	TONS

LEGEND

- W8 x 17 (TOP OF STEEL 2'-4¾" ABOVE CONCRETE)
- W6 x 20 (TOP OF STEEL 2'-11" ABOVE CONCRETE)
- OUTLINE OF SOLAR PANEL
- 3"⌀ x ¼" STRUCTURAL PIPE COLUMN
- OUTLINE OF CONCRETE JOISTS AND BEAMS

ORIGINAL PAGE IS OF POOR QUALITY

FOLDOUT FRAME

2

ERECTION SEQUENCE

1. There are 64 3-inch round pipe columns on this job. 62 of these columns are between 1'-9" long and 2'-11" long. These columns weigh less than 8 pounds per foot. The remaining two columns are approximately 16' long and also weigh in the neighborhood of 8 pounds per foot. These columns would be erected first by drilling two bolt holes into the existing concrete structure and bolting the column down through a 4" x 9" column base plate. No shimming nor grouting would be required between the column base plate and the top of the concrete. Erection of these columns would have to take place over a very short space of time since each day it takes to erect these columns causes a delay in installing the roofing. Erection of the columns would begin June 17, 1976.

2. Approximately 3 months after the erection of the columns the steel shapes would be erected. At this point, the crane would have to be brought to the job with sufficient reach to take the steel to the top of the 6th and 7th floors of the building. These floors are in the neighborhood of 80 and 95 feet respectively above grade. The main steel beams are W 8 X 17 which basically run north and south on the building. These beams would be lifted by the crane directly from the ground and placed on top of the columns and not the existing roof. They would be welded to the top of the columns from above and not from below, as indicated on the structural drawings S-1 and S-2. Once these beams are in place, the W 6 x 20 beams which run diagonally relative to the W 8 beams would be positioned and would not have to be welded at this time. This would allow the crane to move east and west relative to the building rather rapidly. Once all the W 8 beams are in place and welded to the column and all the W 6 beams are placed on top of the W 8 beams, the W 6 beams can then be slid into their exact positions and final welding can take place.

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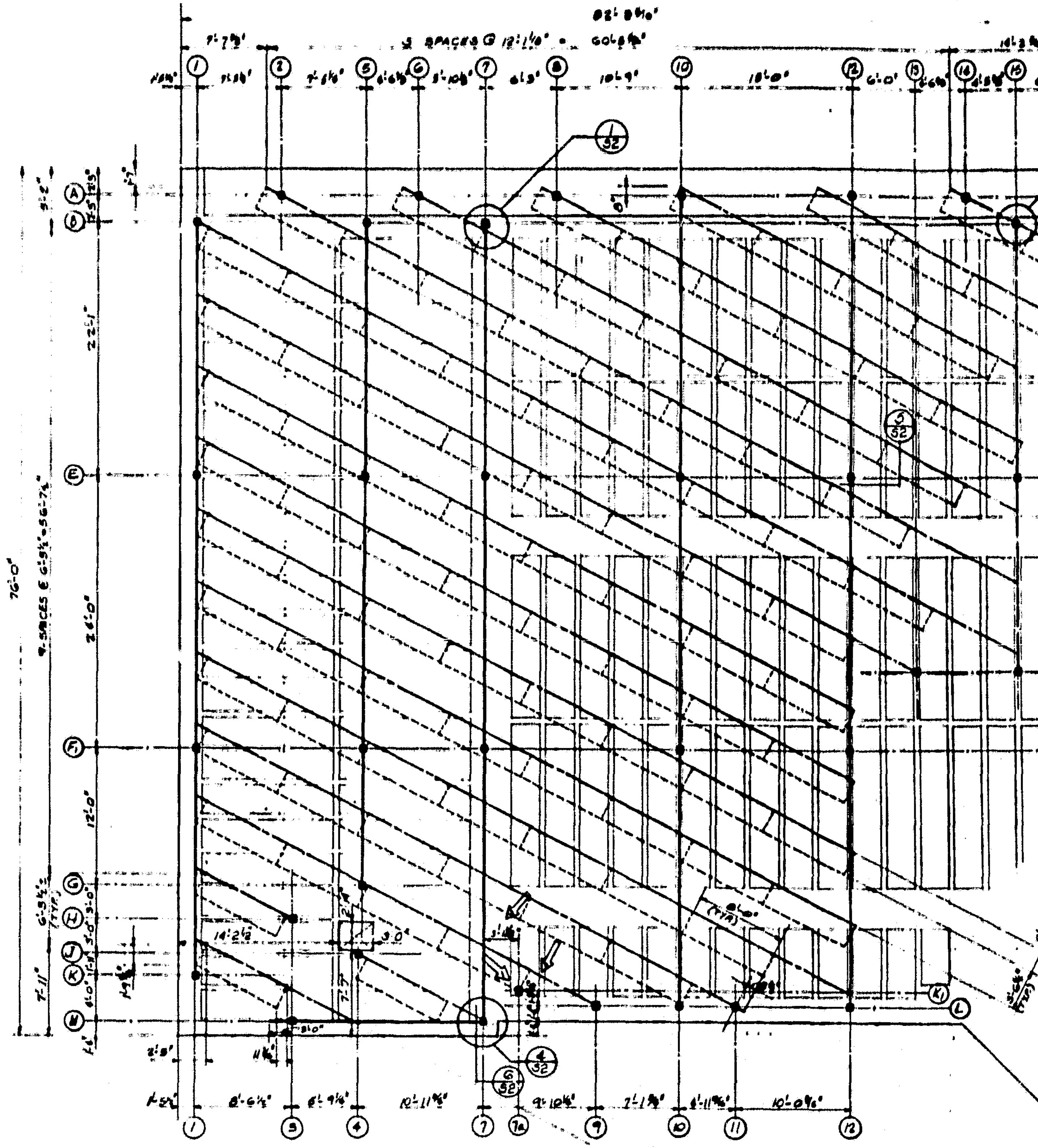
PENTHOUSE ROOF PLAN
STRUCTURAL STEEL
SUPPORTING SYSTEM

SOLAR HEATING
THE AREA HEALTH EDUCATION CENTER
CHARLOTTE, NORTH CAROLINA

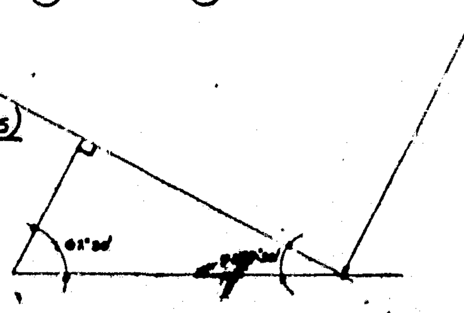
REVISION 6-16-76
PROJECT NO. 238.0001
SHEET NO. S1
DATE 5-24-76



LEGEND

———	W8 x 17 (TOP OF STEEL 2'-4 3/4" ABOVE CONCRETE).
— - —	W6 x 20 (TOP OF STEEL 2'-11" ABOVE CONCRETE).
- - - -	OUTLINE OF SOLAR PANEL
□	3" ø x 1/4" STRUCTURAL PIPE COLUMN
⊢ - - ⊣	OUTLINE OF CONCRETE JOISTS AND BEAMS

ROOF PLAN (100 PANELS)
3/16" = 1'-0"



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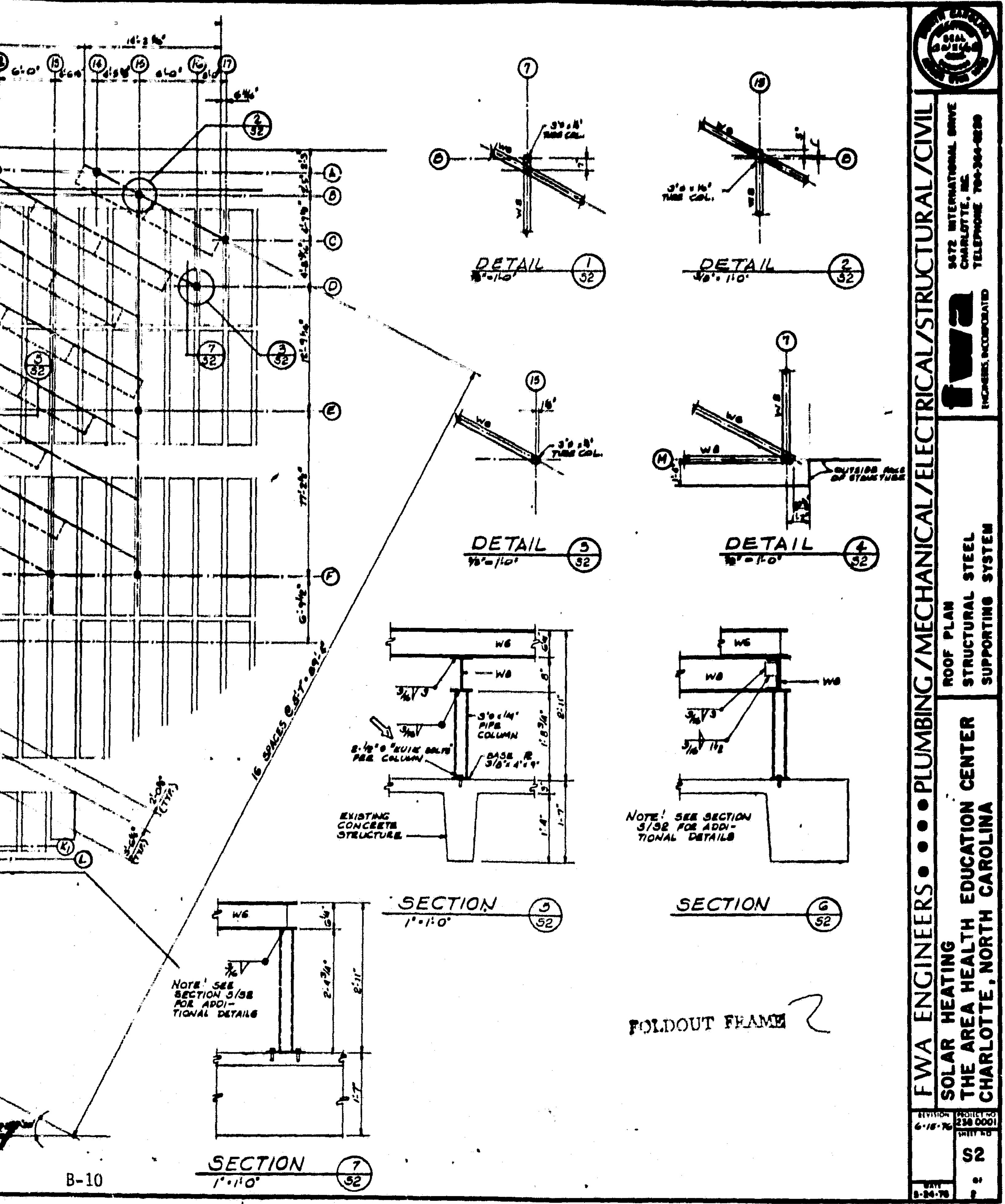

FOLDOUT FRAME 2